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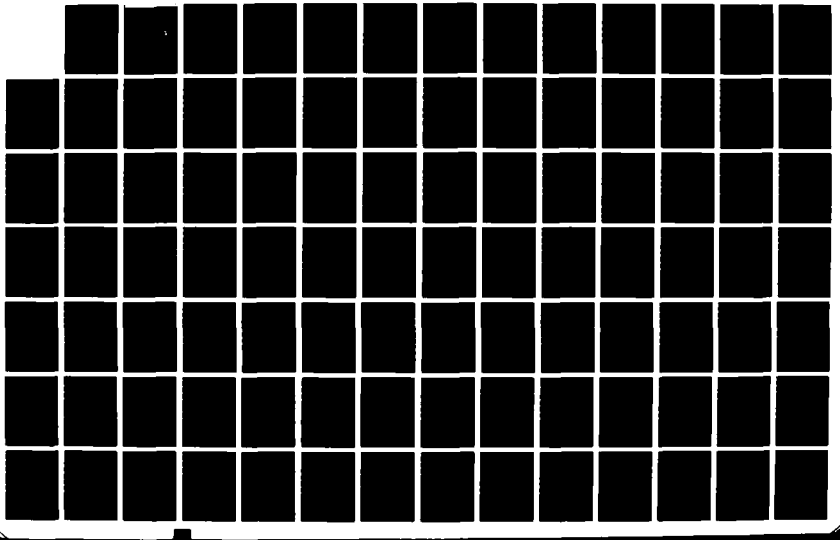

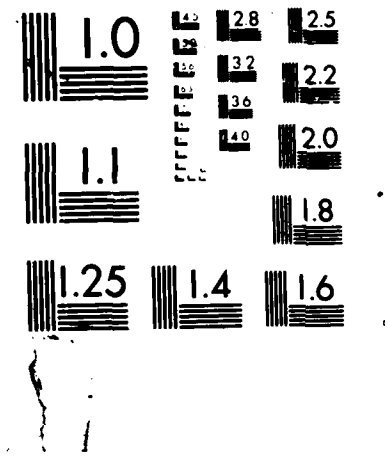
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AUTOMATED INTERIOR LIGHTING DESIGN SOFTWARE FOR BASE CIVIL ENGINEERS

THESIS

Todd A. Grimes
GS-13

AFIT/GEM/LSQ/87S-8

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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AUTOMATED INTERIOR LIGHTING DESIGN SOFTWARE FOR BASE CIVIL ENGINEERS

THESIS

Presented to the Faculty

of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Engineering Management

Todd A. Grimes, B.S.

GS-13

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Todd A. Grimes

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Abstract

Lighting design is a critical part of all building design processes for both new construction and renovation work. Performing lighting design properly takes a large amount of time and effort. The primary objective of this thesis effort was to develop a computer software package that would help base engineers perform the calculation stage of interior lighting design quickly and accurately.

Because the base engineer will have available to him many different types of computer systems, a second objective of this thesis was to make the program as transportable between computer systems as possible. The primary system that the program was designed for was the Wang pc system because of its wide spread use within the Civil Engineering community.

The program developed for this thesis effort is entitled LIGHT1A, and uses the Zonal Cavity Method of lighting design. LIGHT1A was developed to be menu driven to enhance user friendliness, and has a large data base filing system to allow the base engineer to store a number of lamp, fixture, and room color criteria. LIGHT1A was programmed in the language of BASIC to allow transportability between computer systems, and has been tested on the Wang pc, the Zenith Z-248, and the TeleVideo XL.

AUTOMATED INTERIOR LIGHTING DESIGN SOFTWARE FOR BASE CIVIL ENGINEERS

I. Introduction

General Issues

Interior lighting design is one of the many important duties that must be performed by design engineers during a construction project. This is true whether the project is the renovation of a single room or an entire building. It also applies to most, if not all, new construction projects. If accomplished properly, the lighting installation will help ensure that the total construction project has a professional appearance. Also, if the lighting design is considered at the beginning of a design project, instead of as an afterthought, "...the lighting and the architecture can become one cohesive system in meeting the occupant's needs" (33:38).

"Visual accuracy is not all there is to a person's need for light (10:140)." Not only can a person's perceptions of an area be affected by the lighting pattern (33), but quality lighting can increase the performance of the user (10). A well designed lighting system has many positive effects for the user. Two of these positive effects are overall safety in the area and the aspect of

increased task visibility. Also, a good lighting system can reduce the fatigue and unnecessary eye strain that results from poor lighting (7:70). Also studies have shown that the quality and intensity of light might very well affect the biological reactions of people (29)(30). "Light controls biological rhythms, regulates production of hormones, and affects metabolism of specific areas in the brain (30:11)." Simply stated, "Research conducted in the last few years has revealed a number of mechanisms by which light affects our productivity, health, biologic rhythms, moods, and general sense of well being (31:4)."

A problem exists doing lighting designs. Design engineers either spend a great amount of time performing proper design calculations and comparison designs (comparing different lighting designs for the best "fit"), or they use shortcut techniques to allow them to "get the job done." Design time for the typical design engineer is valuable, and shortcut methods which produce minimally acceptable lighting designs are widely used. Fortunately, there is a solution. With the use of a computer, and the proper software, design engineers can produce quality lighting designs in less time, while forgoing less than acceptable shortcut methods. Computers can help design engineers efficiently pull together the large amount of data that is required by good lighting designs (10).

But, what computer system is best in supporting the design engineer? Personal computer (pc) systems such as the Zenith Z-100, along with IBM compatibles like the Zenith Z-150 and Z-248 series, and the TeleVideo XL are all available to the base engineers if their bases can afford to supply them. The Wang computer system, on the other hand, has been selected to support the Air Force Work Information Management System (WIMS), and has been awarded a contract currently known as the Air Force Minicomputer Multi-User System (AMMUS) (13). The WIMS system is specifically intended to supporting the Civil Engineering community of the Air Force. The AMMUS contract calls for the Wang computer system to be installed at 153 Air Force locations in support of the WIMS. Since this computer system will be widely available throughout the Air Force to base civil engineering groups, it is logical for the base engineer to use it for as many applications as possible, including lighting design. A software package on lighting design, capable of working on the Wang computer system, and as many of the other computers listed above as possible, would be ideal for the base design engineer. In this way, no matter what computer system the design engineer has available, the lighting design package could be used.

Background

To acquaint the reader with good lighting design procedures, this background section will summarize the

necessary steps that must be taken by the design engineer while performing a lighting design. Although there are many ways to calculate the amount of light sources needed in a certain space, the most common one, the Zonal Cavity Method, will be described. For those who want a greater understanding of this process in lighting design, Chapter II of this thesis will provide a much more detailed explanation of the process, and also works examples to help in the reader's understanding.

There are three major stages in performing a lighting design. The first stage is the calculation stage which includes the gathering of information necessary to perform the calculations. The second and third stages are the layout and iterative stages of lighting design. The goal of the first stage is to calculate how many light fixtures of a particular type is needed to illuminate a surface to a predetermined level. The second stage is used to place the fixtures in a pattern around the room to eliminate any "dark" spots on the surfaces being lit. The third stage is the repeat stage, where the design engineer reworks the calculation and layout stages over again so that two or more designs can be compared together to enable the "best" design to be picked. This may be the most important stage of all -- and is the one that is skipped when "time is of the essence."

The second stage, the layout stage, of the design process can be loosely considered to be an "art," and most of the time will depend upon the design engineer's background and knowledge. Many rules-of-thumb exist for the layout of the lighting fixtures, but all-in-all the final decision rests squarely on the design engineer's shoulders. "Good lighting design means putting light -- and the right kind of light -- where it is needed" (10:140). Since this is the case, no "canned program" can tell the designer where to ultimately put the light fixtures.

As stated before, the third stage of the lighting design process, the iterative stage, is when the design engineer repeats the first two stages. Multiple designs are necessary because it is unlikely that the design engineer will choose the "best" design the first time, given that there are so many design criteria that must be taken into consideration. This design criteria is the input information needed for the first stage, the calculation stage. As the following paragraphs will explain, there are many different types of lighting systems, including different luminaire types and styles, as well as different types of lamps and ballasts. There is no single "best" solution for all cases, even from office to office, and there is always an alternative (7:73). All this means is that to do a lighting design properly, a

design engineer must perform the design a number of times, each with a little different design concept, and then choose the "best" design for the given situation.

Since the second stage is heavily dependent upon design engineer's choice, and the third stage can be skipped (although not recommended by this thesis effort), the first stage, the calculation stage, is the stage of primary interest. This is the stage, that, when repeated takes the major amount of time. The reason the calculation stages take so long to complete, is not that the calculations are long, but that the information needed to perform the calculations takes quite a bit of time to assemble and interpret.

The information requirements of the calculation stage can be broken into two main parts, the room information, and the luminaire information. (A luminaire can be considered a total light package, including the fixture, or housing, the lens, the lamp, the ballast -- if necessary, and any other item necessary to make the package work.)

The room information necessary to perform a proper lighting design include basic information about the room itself, and about how the room is used. Actual dimensions of the room including its floor area and the ceiling, luminaire and working surface heights must be known. This information is then combined into "factors" called room cavity ratios (RCR's) which ultimately help determine how

the room allows the light to be "spread" out within it. Differently dimensioned rooms will have different RCR factors. Room surface reflectances (how much light a given surface will reflect) is also important information about the room. To use extremes as an example, a room painted totally white will be much brighter than a room painted totally black. The reason for this is that the color white reflects much more light than does the color black. Because of this, the actual room surface colors must be known to determine how much light will be reflected back into the room from the walls, the ceiling, and the floor.

Along with the information about the room itself, information about how the room is used must be known. The actual activity performed in the room will determine the amount of light that is necessary to perform that activity properly. Hallways where people walk and talk do not need nearly the light that is necessary in normal offices where reading and writing occurs, and these offices do not need the quantity of light that is required in a drafting area, or similar areas where fine detailed work occurs. The AFR 88-15, Section 16-10, states that all Air Force installations will be illuminated to a maximum "ambient light level" that matches its specific type of usage (5). This means that for any given room, the general lighting level will not exceed a certain amount. For example, all general office space will not have any more than 50

footcandles (fc) on any given work surface. A footcandle is the amount of light a candle will put out if measured one foot from the flame. Any additional light that is necessary for the user to do his job must be supplied by "task lighting", for example, a desk lamp. Different rooms have different "ambient light levels" allowed for the given use of the room, a conference room is allowed 30 fc, a warehouse is allowed 10 fc.

Closely tied to the room usage is the cleanliness factors of the room. Areas that have a high level or dirt accumulation will have very definite affects on the maintained lighting level in the area. As the dirt accumulates on the rooms surfaces, the surfaces ability to reflect light will be reduced. This cleanliness factor is combined with other light depreciation factors inherent to the luminaire to come up with a total light loss factor (LLF) for the lighting design.

The actual room dimensions, the surface reflectances, the room usage criteria, and the cleanliness factors are the information areas that must be assembled under the room information part of the calculation stage in lighting design. The other part that must be completed prior to the actual calculations being performed is the accumulation of the luminaire information. Whereas the room information is needed to figure out how the room "uses" the light that is in it, the luminaire information is needed to figure out

how much light each fixture will supply to the room and how it will "spread" out the light that it produces.

Luminaires come in many types, styles, and sizes. In general, the design engineer will consider the area usage to determine the type of luminaire to use. Most commonly, incandescents are used only for specialty lighting or for very small areas because of their high energy consumption. Fluorescent luminaires are the most common choice for general office type lighting, whereas high intensity discharge (HID) luminaires are used primarily in warehousing and other high ceiling areas. (Note the words: "most common" and "primarily" are used do to the fact that there are some florescent luminaires made for high ceiling areas, and some HID luminaires made for office applications.) Once the luminaire type is chosen, the base engineer must select the particular style to use. Luminaire style is important because each style of luminaire will have different "light spreading" characteristics. Reflector shape, lens type, and internal mounting distance of the lamp from the lens will cause the light to be dispersed from the luminaire in a particular manner. One way to measure the effectiveness of a luminaire in dispersing the light properly into a room is with a Visual Comfort Probability (VCP) rating. VCP is a number which represents the theoretical number of people out of 100 who may be expected to say that the lighting of

an experimental room is comfortable when lit with a given style of luminaire (28:60). Lamp and ballast types must also be chosen in this part of the information requirements. Different lamps, especially fluorescent, have different color characteristics. For example warm white lamps emphasize the "reds" in a room where cool white lamps emphasize the "blues." Also, lamp and ballast choices must be made carefully because not all lamps and ballasts will work properly together (7:69). Once this information on the luminaire is chosen by the base engineer, it can be used, along with the room information, to complete the design calculations.

Specific Problem

The previous section should have given the reader a greater understanding of the decisions the design engineer must make to perform proper lighting designs. Also, the reader should understand that each stage is vital to a proper design, and shortcut methods, or the "skipping" of any of these stages, will not produce the best design. In addition, the reader should now understand that good lighting design is as much concept or thought oriented as it is calculation oriented.

Captain W. M. Duncan, in his 1983 AFIT thesis on computer-aided design (CAD), states that "any task involving extensive 'number crunching' can be improved by using computers to do the calculations thus freeing the

designer to use his time for other design work" (6:31). Also, not only are computers good for performing calculations, but with the proper software, can actually increase design applications by increasing the conceptual based resources of the engineer (34:1742). The use of computers in engineering work, such as lighting design, is growing in recognition in all parts of the engineering community, and is now being called computer-aided engineering (CAE) (34:1732). Some of the major goals accepted for CAE systems are to: 1) help reduce design time; 2) help induce new ideas into designs; and 3) help train new engineers in analysis applications (34:1744). By incorporating CAE into the design engineer's options for performing lighting designs, better designs can be produced, with less time involved in performing them (3).

As stated in the general issues section, the Wang computer system, since it will be the most widely available computer system to Air Force design engineers in Civil Engineering, is the primary choice for CAE work. Also, as previously stated there are other computer systems available to many base Civil Engineering organizations. Therefore, any CAE software that can be developed for both the Wang system and as many of these other systems as possible would be most beneficial Air Force wide.

The Illuminating Engineering Society (IES) published in the September 1986 issue of its Lighting Design +

Applications periodical a listing of lighting design computer programs for CAE use (1). Of the 16 program suppliers listed, 11 had interior lighting design packages available. Telephone interviews with nine of these 11 suppliers were performed to gain price information and computer system requirements (the other 2 suppliers were recorded messages)(2)(8)(9)(11)(12)(21)(22)(23)(27). The range of prices for the basic lighting programs ran from $420 to $1700. All of the programs required IBM compatible computers to work. Only one of the suppliers thought that his program would run on a Wang pc system, although he had never had it tested on that particular system.

Five of the program suppliers interviewed followed-up with a descriptive package of their particular program (15)(16)(17)(18)(19). Of these, the lighting design program package that looked the most useful (Zonal Cavity method and economic calculations) without extraordinary cost, was priced at $495 (18). Assuming that this program could be modified, if necessary and with permission, for the Wang pc system, and purchased for each of the bases that are to get the Wang system, the cost would be $75,735 ($495 * 153 bases).

Objective

The objective of this thesis effort is to develop a useful software package on interior lighting design, for use by Air Force design engineering personnel. Also, this

software package will be developed to work on as many different types of Air Force computers as possible, but with particular emphasis on the Wang pc computer system.

For widest possible distribution, this software package will be available from the electrical department of the Air Force Institute of Technology's School of Civil Engineering and Services, AFIT/DEE.

II. Interior Lighting Design

Chapter Overview

This chapter expands on the background section in Chapter I. Detailed explanations for each aspect of the room and luminaire information are given. Also an example of each type of calculation is shown to help the reader. Each example given will build upon examples preceding it to show the reader the entire process that must be performed to complete the calculation stage of lighting design.

As indicated in Chapter I, there are three major stages of work that must be done when performing a proper lighting design. These areas are the calculation stage, including the gathering of information on design requirements; the layout stage; and the iteration stage. During the layout stage, the design engineer must ensure that the number of luminaires determined by the calculation stage will fit into the given room. This stage also ensures that the distribution of light is as even as possible throughout the room. Although the design calculations performed in this project's computer program will give the design engineer important criteria pertaining to the layout of the lighting fixtures, they will not ensure that the layout is properly performed.

The iteration stage of a proper lighting design is accomplished when the design engineer performs the stages again, with different luminaire information. This stage, as stated in Chapter I, is performed to ensure that the "best" design is produced.

Because the layout stage is outside the scope of this project, and the iterative stage is simply a re-enactment of the first two stages, the scope of this chapter will be limited to describing the calculation stage of a lighting design.

The ultimate goal of the calculation stage is to determine the number of luminaires required to light a given area to an ambient level. Prior to these calculations though, information about the area being designed, and information about the luminaire to be used must be known. This chapter will discuss these information requirements, and then show how this information is used in performing the calculations necessary to obtain the number of luminaires needed for a proper lighting design.

It is important to state here that the entire knowledge base for this chapter comes from five major sources, with one of the sources being the author's knowledge from nine years of experience in lighting design. The other sources used to back up this experience are the following:

1) the IES Lighting Handbook (14),

2) the AFR 88-15 (5),

3) classroom handouts on lighting design, given out by the AFIT School of Civil Engineering and Services (25),

4) seminar notes and catalog data from the General Electric's basic lighting school in Cleveland, Ohio (20).

General

Prior to performing the actual calculations to determine the number of lights required to illuminate a given area to an ambient level, information must be gathered to support the calculations. Specific factors of the calculations that must be supported by the gathering of information are the total light loss factor (LLF), the coefficient of utilization (CU) value, the total lumen requirements of the room, and the luminaire spacing requirements used for the layout stage of lighting design. Although these factors will be discussed in detail later, a general description will be given here to help the reader understand the basis or need of the information required to perform the calculations.

The total light loss factor (LLF) is calculated by combining all the possible ways to decrease the light actually given off in the room by the fixtures. Factors such as how clean the room is, how new the lamps are, and

what kind of luminaire enclosure is used are included in this total LLF. The coefficient of utilization (CU) value is determined by combining how the given area will "use" the light and how the luminaire itself will spread the light out over that area. To calculate the total lumens required in the room, the above factors are combined with information about the allowable lighting level and the area's actual dimensions. These three factors, the LLF, the CU value, and the total lumens required, along with other luminaire information lead to the final calculation of the total number of luminaires required in the area. The final factor in the calculations is the determination of the luminaire spacing. Actual luminaire information and the area's dimensions are *combined* to determine this factor.

Information Requirements

The information requirements that support the calculations can be separated into two main areas, the room information and the luminaire information. Room information includes items such as room usage, size, surface reflectiveness, and cleanliness. The actual use of the room will determine what lighting level is allowed. The dimensions of the room must be known to determine how the light can be "spread" out over the area. The room's surfaces will "reflect" the light given off by the fixtures within the room, and according to how much this

reflection is, will partially determine how many fixtures must be used in the area. The room cleanliness must be known in order to determine how much of the original room's reflectances will be lost due to dirty conditions as time goes on. These for factors of room information must be known prior to the design calculations being performed, to ensure design accuracy.

Luminaire information such as the light source type, the fixture type, and the lamp and ballast type must also be known. There are three major light source types available in many different types of enclosures or "fixtures." Each different fixture type will distribute or "spread" the light given off by the light source differently. Lamp information must be known to determine how much "light" the chosen lamp will give off, and certain types of lamps require ballasts to work properly. Ballasts also come in many styles, although once the lamp is chosen, the associated ballast choice is somewhat limited. This information on the luminaire chosen to be used, must be known for input into the design calculations.

To optimize a lighting design, the design engineer should compare different lighting calculations on each room under consideration. Once different calculations are completed and compared, the "best" system can be chosen. Since in this process the room information stays the same,

multiple sets of luminaire information should be assembled enabling different lighting systems to calculated.

Room Information

Lighting levels. The first item that must be determined in a lighting design is the allowed illumination level of a room. To do this, the room's intended use must be known. Will it be an office, a conference room, a computer room, or something different? In Air Force applications, the AFR 88-15 Section 16-10 gives the design engineer a listing of allowed lighting levels for an assortment of room types. Table 2.1 is a combination of Tables 16-1 and 16-2 of Section 16-10 of the AFR 88-15 (5).

It is important to note the written instructions that go along with these tables from the AFR 88-15, especially the parts that indicate that these lighting levels are for "general" or ambient illumination, and that "supplementary" lighting must be used if more light is required for a specific task. It is also important to know that the AFR 88-15 states that 75 footcandles (fc) maintained is the maximum illumination level allowed, no matter what the room is used for. (Footcandles are the units that quantities of light are measured in.)

Once the illumination level is determined for the room, the design engineer must figure out how the room itself will enhance or detract from the "spreading" of

Table 2.1 -- Allowable FC Levels

AREA	FOOTCANDLES
Accounting Rooms	75
Auditoriums	20
Cafeterias	25
Computer Rooms	50
Conference Rooms	30
Corridors	10
Drafting Rooms	75
Elevator Machine Rooms	15
Emergency Generator Rooms	15
Garage Entrance	30
General Office Space	50
Janitor's Closets	5
Kitchens	70
Lobbies	15
Lounges	15
Mechanical Rooms	15
Stairways	20
Storage Rooms	5
Switchgear Rooms	15
Toilets	20
Transformer Vaults	15
Warehousing, Note 1:	
Inactive	5
Active-bulk	10, Note 2
Rack	20
Bin	5, Note 3
Mechanical Material Handling:	
Control Centers	30
Loading Areas	20
Accumulation Conveyer Lines (unmanned)	10

Notes:

1. Intensity measured 4 feet from the floor.
2. Main aisles may be lighted to 15 fc.
3. Specialized bin lighting may be provided by user, as required.

light. The room dimensions and surface reflectances are used to figure this function out.

Room Dimensions and Ratios. The actual dimensions of the room must next be used to figure out the "room cavity ratios." All rooms, theoretically, have three "room cavities," although in practice one or two of these cavities may be equal to zero. These cavities are best understood by looking at Figure 2.1 which is similar to Figure 9-9 of the IES Lighting Handbook (14).

The ceiling cavity (CCR) is the area between the actual room ceiling and the bottom of the light fixtures. This cavity will be equal to zero if the fixtures are "recessed" into or flush with the ceiling. The room cavity (RCR) is the area between the bottom of the light fixture and the "working plane," where the working plane is defined as the height the activity in the room is being performed at. The room cavity is never zero. The floor cavity (FCR) is the area between the working plane and the floor of the room. This cavity may be equal to zero if the working plane is the floor. The sizes and shapes of these cavities affect the light distribution throughout the room.

Room Cavity Ratios (RCR's) are calculated for each of the previously defined cavities to help enumerate just how each cavity will affect the lighting distribution These ratios are more than just ratios for the given areas, but are also numerical descriptions of how the room is

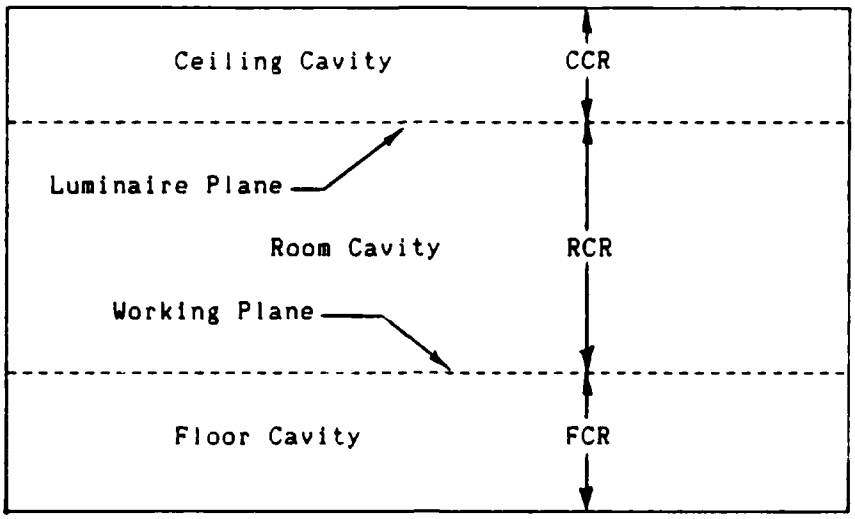


Figure 2.1 -- Room Cavities

dimensioned. Two rooms, having the same overall area, will not have the same distribution of light if their physical shapes are different. Consequently they will have different RCR values. As an example, a square room will not distribute the light the same as a rectangle room, and will require a different fixture layout, even though both rooms have the same dimensional areas (see Example 2.1). The IES Handbook (14) gives the formula for calculating the RCR's of a given room as:

$$5(H)(L+W) \;/\; (L)(W) \qquad (2.1)$$

where

H = the height of the given cavity (CCR, RCR, FCR),

L = the length of the room, and

W = the width of the room

or:

$$2.5(H)(P) / (A) \qquad (2.2)$$

where

H = the height of the given cavity,

P = the perimeter measurement of the given cavity, and

A = the area of the given cavity's base (ie., floor or ceiling)

Equation (2.2) must be used for rooms that have irregular shapes (rooms other than square or rectangle).

Example 2.1

Purpose: To demonstrate the calculation of RCR's.

Room #1 dimensions:

length	=	40 ft
width	=	40 ft
ceiling height	=	10 ft
fixture height	=	8 ft
working plane hgt	=	2.5 ft

Room #1 Cavity Ratios:

$$CCR = (5)(2)(40+40) / (40)(40)$$
$$= 0.500$$

$$RCR = (5)(5.5)(40+40) / (40)(40)$$
$$= 1.375$$

$$FCR = (5)(2.5)(40+40) / (40)(40)$$
$$= 0.625$$

(note: Room #1 area = 1600 ft^2)

Example 2.1 continued

Room #2 dimensions:

length	=	80 ft
width	=	20 ft
ceiling height	=	10 ft
fixture height	=	8 ft
working plane hgt	=	2.5 ft

Room #2 Cavity Ratios:

$$CCR = (5)(2)(80+20) / (80)(20) = 0.625$$

$$RCR = (5)(5.5)(80+20) / (80)(20) = 1.719$$

$$FCR = (5)(2.5)(80+20) / (80)(20) = 0.781$$

(note: Room #2 area = 1600 ft^2)

The informational requirements of the room for the above calculations are simply the room's length and width (or perimeter and area), and the heights of the ceiling, the light fixtures, and the working plane. With these dimensions, the RCR's of the given room can be obtained. These values, along with the room reflectivity ratios, can be combined to determine the total room's contribution to the distribution of light.

Room Surface Reflectances. Along with determining how the room dimensions allow light to be distributed within the room, the "surface reflectances" of the room must be evaluated to determine how the light within the room is "reflected" from all non-working surfaces onto the working

surface. In lighting design, each room surface, other than the working surface, will be given a number representing the percent reflectance for that surface. These surfaces include the ceiling, the walls, and the floor.

There are two major items that will determine a surface's percent reflectance. The first is the color of the surface; a white wall will reflect light better than a medium blue wall, which in turn will reflect light better than a black wall. Table 2.2 shows a variety of colors and their respective reflectance numbers. If a surface could be made perfectly reflective, it would be assigned a number of 1.0 (ie. 100%). In other words, the surface would reflect back exactly the same amount of light shown onto it. A mirror would have a reflectance very close to 1.0. The reflectances given in Table 2.2 were determined in a laboratory setting by the paint manufacture, and are published and distributed along with the manufacturer's color chip sets (sets of all colors that are available, normally given to architectural designers to help in room color selections) (4).

The second item that must be considered when determining the reflectivity of a surface is the surface's texture. A rough, pitted surface will not reflect as much light as a smooth surface. Although there are no tables or charts available to show the "lost" reflectivity for

Table 2.2 -- Color Reflectance Ratios

COLOR	REFLECTANCE RATIO (P_x)
Cameo White	0.86
Winter White	0.83
Lemon	0.84
Manilla Beige	0.77
Pink Marble	0.74
Butte Orange	0.31
Lavender Rose	0.39
Pale Violet	0.74
Violet Grey	0.52
Blue Daisy	0.62
Iceberg	0.77
Crayon Blue	0.20
Colonial Green	0.69
Pastel Green	0.69
Mint Haze	0.75
Silver Lining	0.70
Dawn Gray	0.77
Sand Tan	0.68
Ocean Sand	0.63

differently textured surfaces, the design engineer must be aware that the loss exists, and adjust the reflectances as he sees fit.

If there is a ceiling cavity and/or a floor cavity, the ceiling and floor reflectances must be adjusted for the amount of light that is "lost" within that respective cavity. Some of the light that enters into those cavities never reaches the working surface, and that "lost" contribution must be subtracted from the respective surface's reflectance when it is used to determine the room's overall contribution to the lighting design. The ceiling and floor reflectances must be adjusted to what is

called by the IES Lighting Handbook (14) the "effective reflectances" if there is a ceiling or floor cavity respectively. Table 2.3 is a reproduction of Figure 9-11 of the IES Lighting Handbook (14), and gives the effective reflectances for various cavity ratios versus actual wall and base (ceiling or floor) and reflectances. The numbers given in Table 2.3 can be considered linearly related which allows extrapolation to be done for non-tabled numbers.

Design information requirements to figure out the room's reflectance values are the room surface colors and textures, and the cavity ratios for the ceiling and floor areas. These reflectance values, along with the previously discussed RCR's allow the design engineer to assign numbers for the room's contribution to the distribution of light throughout its area. These numbers will be combined into what has been explained as the "coefficient of utilization" (CU) value which will help calculate the number of fixtures needed to light a room to the proper level. This procedure is accomplished after the luminaire information is identified, and a fixture is chosen.

Example 2.2

Purpose: To calculate an effective ceiling cavity reflectance ratio for Room #1 of Example 2.1.

Room Information: Ceiling Cavity Ratio (CCR) = 0.5

Table 2.3 -- Effective Reflectances

Per Cent Base* Reflectance	90										80										70										60										50									
Per Cent Wall Reflectance	90	80	70	60	50	40	30	20	10	0	90	80	70	60	50	40	30	20	10	0	90	80	70	60	50	40	30	20	10	0	90	80	70	60	50	40	30	20	10	0	90	80	70	60	50	40	30	20	10	0
Cavity Ratio																																																		
0 2	89	88	88	87	86	85	85	84	84	82	79	78	78	77	77	76	76	75	74	72	70	69	68	68	67	67	66	66	65	64	60	59	59	59	58	57	56	56	55	53	50	50	49	49	48	48	47	46	46	44
0 4	88	87	86	85	84	83	81	80	79	76	79	77	76	75	74	73	72	71	70	68	69	68	67	66	65	64	63	62	61	58	60	59	59	58	57	55	54	53	52	50	50	49	48	48	47	46	45	45	44	42
0 6	87	86	84	82	80	79	77	76	74	73	78	76	75	73	71	70	68	66	65	63	69	67	65	64	63	61	59	58	57	54	60	58	57	56	55	53	51	51	50	46	50	48	47	46	45	44	43	42	41	38
0 8	87	85	82	80	77	75	73	71	69	67	78	75	73	71	69	67	65	63	61	57	68	66	64	62	60	58	56	55	53	50	59	57	56	55	54	51	48	47	46	43	50	48	47	45	44	42	40	39	38	36
1 0	86	83	80	77	75	72	69	66	64	62	77	74	72	69	67	65	62	60	57	55	68	65	62	60	58	55	53	52	50	47	59	57	55	53	51	48	45	44	43	41	50	48	46	44	43	41	38	37	36	34
1 2	85	82	78	75	72	69	66	63	60	57	76	73	70	67	64	61	58	55	53	51	67	64	61	59	57	54	50	48	46	44	59	56	54	51	49	46	44	42	40	38	50	47	45	43	41	39	36	35	34	29
1 4	85	80	77	73	69	65	62	59	57	52	76	72	68	65	62	59	55	53	50	48	67	63	60	58	55	51	47	45	44	41	59	56	53	49	47	44	41	39	38	36	50	47	45	42	40	38	35	34	32	27
1 6	84	79	75	71	67	63	59	56	53	50	75	71	67	63	60	57	53	50	47	44	67	62	59	56	53	47	45	43	41	38	59	55	52	48	45	42	39	37	35	33	50	47	44	41	39	36	33	32	30	26
1 8	83	78	73	69	64	60	56	53	50	48	75	70	66	62	58	54	50	47	44	41	66	61	58	54	51	46	42	40	38	35	58	55	51	47	44	40	37	35	33	31	50	46	43	40	38	35	31	30	28	25
2 0	83	77	72	67	62	56	53	50	47	43	74	69	64	60	56	52	48	45	41	38	66	60	56	52	49	45	40	38	36	33	58	54	50	46	43	39	35	33	31	29	50	46	43	40	37	34	30	28	26	24
2 2	82	76	70	65	59	54	50	47	44	40	74	68	63	58	54	49	45	42	38	35	66	60	55	51	48	43	38	36	34	32	58	53	49	45	42	37	34	31	29	28	50	46	42	38	36	33	29	27	24	22
2 4	82	75	69	64	58	53	48	45	41	37	73	67	61	56	52	47	43	40	36	33	65	60	54	50	46	41	37	35	32	30	58	53	48	44	41	36	32	30	27	26	50	46	42	37	35	31	27	25	23	21
2 6	81	74	67	62	56	51	46	42	38	35	73	66	60	55	50	45	41	38	34	31	65	59	54	49	45	40	35	33	30	28	58	53	48	43	39	35	31	28	26	24	50	46	41	37	34	30	26	23	21	20
2 8	81	73	66	60	54	49	44	40	36	34	73	65	59	53	48	43	39	36	32	29	65	59	53	48	43	38	33	30	28	26	58	53	47	43	38	34	29	27	24	22	50	46	41	36	33	29	25	22	20	19
3 0	80	72	64	58	52	47	42	38	34	30	72	65	58	52	47	42	37	34	30	27	64	58	52	47	42	37	32	29	27	24	57	52	46	42	37	32	28	25	23	20	50	45	40	36	32	28	24	21	19	17
3 2	79	71	63	56	50	45	40	36	32	28	72	65	57	51	45	40	35	33	28	25	64	58	51	46	40	36	31	28	25	23	57	51	45	41	36	31	27	23	22	18	50	44	39	35	31	27	23	20	18	16
3 4	79	70	62	54	48	43	38	34	30	27	71	64	56	49	44	39	34	32	27	24	64	57	50	45	39	35	29	27	24	22	57	51	45	40	35	30	26	23	20	17	50	44	39	35	30	26	22	19	17	15
3 6	78	69	61	53	47	42	36	32	28	25	71	63	54	48	43	38	32	30	25	23	63	56	49	44	38	33	28	25	22	20	57	50	44	39	34	29	25	22	19	16	50	44	39	34	29	25	21	18	16	14
3 8	78	69	60	51	45	40	35	31	27	23	70	62	53	47	41	36	31	28	24	22	63	56	49	43	37	32	27	24	21	19	57	50	43	38	33	28	24	21	19	15	50	44	38	34	29	25	21	17	15	13
4 0	77	69	58	51	44	39	33	29	25	22	70	61	53	46	40	35	30	26	22	20	63	55	48	42	36	31	26	23	20	17	57	49	42	37	32	28	23	20	18	14	50	44	38	33	28	24	20	17	15	12
4 2	77	62	57	50	43	37	32	28	24	21	69	60	52	45	39	34	29	25	21	18	62	55	47	41	35	30	25	22	19	16	56	49	42	37	32	27	22	19	17	14	50	43	37	32	28	24	20	17	14	12
4 4	76	61	56	49	42	36	31	27	23	20	69	60	51	44	38	33	28	24	20	17	62	54	46	40	34	29	24	21	18	15	56	49	42	36	31	27	22	19	16	13	50	43	37	32	27	23	19	16	13	11
4 6	76	60	55	47	40	35	30	26	22	19	69	59	50	43	37	32	27	23	19	15	62	53	45	39	33	28	24	21	17	14	56	49	41	35	30	26	21	18	16	13	50	43	36	31	26	22	18	15	13	10
4 8	75	59	54	46	39	34	28	25	21	18	68	58	49	42	36	31	26	22	18	14	62	53	45	38	32	27	23	20	16	13	56	48	41	34	29	25	21	18	15	12	50	43	36	31	26	22	18	15	12	09
5 0	75	59	53	45	38	33	28	24	20	16	68	58	48	41	35	30	25	21	18	14	61	52	44	36	31	26	22	19	16	12	56	48	40	34	28	24	20	17	14	11	50	42	35	30	25	21	17	14	12	09
6 0	73	61	49	41	34	29	24	20	16	11	66	55	44	38	31	27	22	19	15	10	60	51	41	35	28	24	19	16	13	09	55	45	37	31	25	21	17	14	11	07	50	42	34	29	23	19	15	13	10	06
7 0	70	58	45	38	30	27	21	18	14	08	64	53	41	35	28	24	19	16	12	07	58	48	38	32	26	22	17	14	11	06	54	43	35	30	24	20	15	12	09	05	49	41	32	27	21	18	14	11	08	05
8 0	68	55	42	35	27	23	18	15	12	06	62	50	38	32	25	21	17	14	11	05	57	46	35	29	23	19	15	13	10	05	53	42	33	28	22	18	14	11	08	04	49	40	30	25	19	16	12	10	07	03
9 0	66	52	38	31	25	21	16	14	11	05	61	49	36	30	23	19	15	13	10	04	56	45	33	27	21	18	14	12	09	04	52	40	31	26	20	16	12	10	07	03	48	39	29	24	18	15	11	09	07	03
10 0	65	51	36	29	22	19	15	11	09	04	59	48	33	27	21	18	14	11	08	03	55	43	31	25	19	16	12	10	08	03	51	39	29	24	18	15	11	09	07	02	47	37	27	22	17	14	10	08	06	02

* Ceiling, floor or floor of cavity

Table 2.3 -- Effective Reflectances (continued)

Per Cent Base* Reflectance	40										30										20										10										0									
Per Cent Wall Reflectance	90	80	70	60	50	40	30	20	10	0	90	80	70	60	50	40	30	20	10	0	90	80	70	60	50	40	30	20	10	0	90	80	70	60	50	40	30	20	10	0	90	80	70	60	50	40	30	20	10	0
Cavity Ratio																																																		
0.2	40	40	39	39	39	38	38	37	36	36	31	31	30	30	29	29	29	28	28	27	21	20	20	20	20	20	19	19	19	17	11	11	11	10	10	10	10	09	09	09	02	02	02	01	01	01	01	00	00	0
0.4	41	40	39	39	38	37	36	35	34	34	31	31	30	30	29	28	28	27	26	25	22	21	20	20	20	19	19	18	18	16	12	11	11	11	11	10	10	09	09	08	04	03	03	02	02	02	01	01	00	0
0.6	41	40	39	38	37	36	34	33	32	31	32	31	30	29	28	27	26	26	25	23	23	21	21	20	19	19	18	18	17	15	13	13	12	11	11	10	10	09	08	08	05	05	04	03	03	02	02	01	01	0
0.8	41	40	38	37	36	35	33	32	31	29	32	31	30	29	28	26	25	25	23	22	24	22	21	20	19	19	18	17	16	14	15	14	13	12	11	10	10	09	08	07	07	06	05	04	04	03	02	02	01	0
1.0	42	40	38	37	35	33	32	31	29	27	33	32	30	29	27	25	24	23	22	20	25	23	22	20	19	18	17	16	15	13	16	14	13	12	12	11	10	09	08	07	08	07	06	05	04	03	02	02	01	0
1.2	42	40	38	36	34	32	30	29	27	25	33	32	30	28	27	25	23	22	21	19	25	23	22	20	19	17	17	16	14	12	17	15	14	13	12	11	10	09	07	06	10	08	07	06	05	04	03	02	01	0
1.4	42	39	37	35	33	31	29	27	25	23	34	32	30	28	26	24	22	21	19	18	26	24	22	20	18	17	16	15	13	12	18	16	14	13	12	11	10	09	07	06	11	09	08	07	06	04	03	02	01	0
1.6	42	39	37	35	32	30	27	25	23	22	34	33	29	27	25	23	22	20	18	17	26	24	22	20	18	17	16	15	13	11	19	17	15	14	12	11	09	08	07	06	12	10	09	07	06	05	03	02	01	0
1.8	42	39	36	34	31	29	26	24	22	21	35	33	29	27	25	23	21	19	17	16	27	25	23	20	18	17	15	14	12	10	19	17	15	14	13	11	09	08	06	05	13	11	09	08	07	05	04	03	01	0
2.0	42	39	36	34	31	28	25	23	21	19	35	33	29	26	24	22	20	18	16	14	28	25	23	20	18	16	15	13	11	09	20	18	16	14	13	11	09	08	06	05	14	12	10	09	07	05	04	03	01	0
2.2	42	39	36	33	30	27	24	22	19	18	36	32	29	26	24	22	19	17	15	13	28	25	23	20	18	16	14	12	10	09	21	19	16	14	13	11	09	07	06	05	15	13	11	09	07	06	04	03	01	0
2.4	43	39	35	33	29	27	24	21	18	17	36	32	29	26	24	22	19	16	14	12	29	26	23	20	18	16	14	12	10	08	22	19	17	15	13	11	09	07	06	05	16	13	11	09	08	06	04	03	01	0
2.6	43	39	35	32	29	26	23	20	17	15	36	32	29	25	23	21	18	16	14	12	29	26	23	20	18	16	14	11	09	08	23	20	17	15	13	11	09	07	06	04	17	14	12	10	08	06	05	03	02	0
2.8	43	39	35	32	28	25	22	19	16	14	37	33	29	25	23	21	17	15	13	11	30	27	23	20	18	15	13	11	09	07	23	20	18	16	13	11	09	07	05	03	17	15	13	10	08	07	05	03	02	0
3.0	43	39	35	31	27	24	21	18	16	13	37	33	29	25	22	20	17	15	12	10	30	27	23	20	17	15	13	11	09	07	24	21	18	16	13	11	09	07	05	03	18	16	13	11	09	07	05	03	02	0
3.2	43	39	35	31	27	23	20	17	15	13	37	33	29	25	22	19	16	14	12	10	31	27	23	20	17	15	12	11	09	06	25	21	18	16	13	11	09	07	05	03	19	16	14	11	09	07	05	03	02	0
3.4	43	39	34	30	26	23	20	17	14	12	37	33	29	25	22	19	16	14	11	09	31	27	23	20	17	15	12	10	08	06	26	22	18	16	13	11	09	07	05	03	20	17	14	12	09	07	05	03	02	0
3.6	44	39	34	30	26	22	19	16	14	11	38	33	29	24	21	18	15	13	10	09	32	27	23	20	17	15	12	10	08	05	26	22	19	16	13	11	09	06	04	03	20	17	15	12	10	08	05	04	02	0
3.8	44	38	33	29	25	22	18	16	13	10	38	33	28	24	21	18	15	13	10	08	32	28	23	20	17	15	12	10	07	05	27	23	19	17	14	11	09	06	04	02	21	18	15	12	10	08	05	04	02	0
4.0	44	38	33	29	25	21	18	15	12	10	38	33	28	24	21	18	14	12	09	07	33	28	23	20	17	14	11	09	07	05	27	23	20	17	14	11	09	06	04	02	22	18	15	13	10	08	05	04	02	0
4.2	44	38	33	29	24	21	17	15	12	10	38	33	28	24	20	17	14	12	09	07	33	28	23	20	17	14	11	09	07	04	28	24	20	17	14	11	09	06	04	02	22	19	16	13	10	08	06	04	02	0
4.4	44	38	33	28	24	20	17	14	11	09	39	33	28	24	20	17	14	11	09	06	34	28	24	20	17	14	11	09	07	04	28	24	20	17	14	11	08	06	04	02	23	19	16	13	10	08	06	04	02	0
4.6	44	38	32	28	23	19	16	14	11	08	39	33	28	24	20	17	13	10	08	06	34	29	24	20	17	14	11	09	07	04	29	25	20	17	14	11	08	06	04	02	23	20	17	13	11	08	06	04	02	0
4.8	44	38	32	27	22	19	16	13	10	08	39	33	28	24	20	17	13	10	08	05	35	29	24	20	17	13	10	08	06	04	29	25	20	17	14	11	08	06	04	02	24	20	17	14	11	08	06	04	02	0
5.0	45	38	31	27	22	19	15	13	10	07	39	33	28	24	19	16	13	10	08	05	35	29	24	20	16	13	10	08	06	04	30	25	20	17	14	11	08	06	04	02	25	21	17	14	11	08	06	04	02	0
6.0	44	37	30	25	20	17	13	11	08	05	39	33	27	23	18	15	11	09	06	04	36	30	24	20	16	13	10	08	05	02	31	26	21	18	14	11	08	06	03	01	27	23	18	15	12	09	06	04	02	0
7.0	44	36	29	24	19	16	12	10	07	04	40	33	26	22	17	14	10	08	05	03	36	30	24	20	15	12	09	07	04	02	32	27	21	17	13	11	08	06	03	01	28	24	19	15	12	09	06	04	02	0
8.0	44	35	28	23	18	15	11	09	06	03	40	33	26	21	16	13	09	07	04	02	37	30	23	19	15	12	08	06	03	01	33	27	21	17	13	10	07	05	03	01	30	25	20	15	12	09	06	04	02	0
9.0	44	35	26	21	16	13	10	08	05	02	40	33	25	20	15	12	09	07	04	02	37	29	23	19	14	11	08	06	03	01	34	28	21	17	13	10	07	05	02	01	31	25	20	15	12	09	06	04	02	0
10.0	43	34	25	20	15	12	08	07	05	02	40	32	24	19	14	11	08	06	03	01	37	29	22	18	13	10	07	05	03	01	34	28	21	17	12	10	07	05	02	01	31	25	20	15	12	09	06	04	02	0

* Ceiling, floor or floor of cavity

Example 2.2 continued

From Table 2.2:

Ceiling Color: Winter White
reflectance: (P_c) = 0.83

Wall color: Silver Lining
reflectance: (P_w) = 0.70

Ceiling Cavity effective reflectance:

From Table 2.3	Table Reading
with base reflectance = 0.80 and wall reflectance = 0.70	
for CCR = 0.4	P_{eff1} = 0.76
for CCR = 0.6	P_{eff2} = 0.75
1st extrapolation:	
for CCR = 0.5	P_{effA} = 0.775
with base reflectance = 0.90 and wall reflectance = 0.70	
for CCR = 0.4	P_{eff3} = 0.86
for CCR = 0.6	P_{eff4} = 0.84
2nd extrapolation:	
for CCR = 0.5	P_{effB} = 0.85

Final extrapolation (between P_{effA} & P_{effB}):

for ceiling reflectance = 0.83
and wall reflectance = 0.70

Ceiling Cavity Effective Reflectance (P_{cc}) = 0.78

Room Cleanliness. Prior to discussing the luminaire information requirements, one last item must be determined under the topic of room information requirements. This

item is the room's "dirt condition." In most construction, when new lighting is installed in an area, the area is left in a relatively "clean" state. Fixtures are new, painted surfaces are fresh, and the general condition of the area is good. Unfortunately, in most cases, the area starts to accumulate dirt after a period of time. Periodic cleaning, at least in offices, is good, but fixtures are normally not cleaned and walls almost never get washed. Dirty fixtures and surfaces cannot give off or reflect as much light as they did when new, causing the room's lighting conditions to be less than optimal. Table 2.4 is similar to Figure 9-4 of the IES Lighting Handbook (14) which separates room cleanliness into "five degrees of dirt conditions." The design engineer must determine what degree the given area best fits into, and record this condition for reference when calculating a total light loss factor (LLF) in the calculation stage of the design. The length of time between overall cleaning must also be noted, or guessed at, by the design engineer for calculation of the LLF. This time is normally recorded in months, with a good guess being between 24 and 36 months from cleaning to cleaning.

Summary. Determining the room information requirements is the first step in performing a proper lighting design. The room's actual use, the dimensional contribution to the distribution of light including both

Table 2.4 -- Room Dirt Conditions

	Very Clean	Clean	Medium	Dirty	Very Dirty
Generated Dirt	None	Very Little	Noticeable but not heavy	Accumulates rapidly	Constant accumulation
Ambient Dirt	None (or none enters area)	Some (almost none enters)	Some enters area	Large amount enters area	Almost none excluded
Removal or Filtration	Excellent	Better than average	Poorer than average	Only fans or blowers if any	None
Adhesion	None	Slight	Enough to be visible after some months	High -- probably due to humidity, oil or static	High
Examples	High grade offices, not near production; clean rooms	Offices in older bldgs or near production	Mill offices; paper processing	Heat treating; high speed printing	Similar to Dirty, but luminaires within area of contamination

the cavity sizes and the surface reflectance amounts, and the room cleanliness factors are the items that need to be determined in the room information gathering process. This information must be combined with the luminaire information to enable the calculations stage of lighting design to be performed properly.

In an effort to help with further examples, Chart 2.1 is the accumulation of all information that must be known about the room. Chart 2.1 includes the calculated data from Examples 2.1 and 2.2, as well as additional data calculated using similar methods (ie. the effective floor cavity reflectance). Chart 2.1 will be used for comparison purposes in Chapter IV, during the program validation sequence.

Chart 2.1 -- Room Information

Data		Source
Room Use:	Office	Given
FC Required:	50 fc	Table 2.1
Room Dimensions:		Room #1, Example 2.1
length:	40 ft	
width:	40 ft	
area:	1600 ft^2	
ceiling hgt:	10 ft	
fixture hgt:	8 ft	
working hgt:	2.5 ft	
Room Cavity Ratios:		Example 2.1
CCR:	0.5	
RCR:	1.375	
FCR:	0.625	
Room Surface Colors:		Given
ceiling:	Winter White	
walls:	Silver Lining	
floor:	Crayon Blue	
Room Surface Reflectances:		Table 2.2
P_c:	0.83	
P^w:	0.70	
P_f:	0.20	
P^{cc}:	0.78	Example 2.2
P_{fc}:	0.21	Calculated
Room Dirt Condition:	Clean	Table 2.4
Cleaning Cycle:	18 months	Chosen

Luminaire Information

General. Now that the room information requirements have been discussed, the next area of interest is the light luminaire information. This information can be broke down into three main topics for discussion; the light source

type, the source enclosure or "fixture," and the source lamp and ballast requirements.

Light Sources. There are three major types of light sources to choose from when doing interior lighting design. These major types of sources include incandescent, fluorescent, and high intensity discharge (HID). Each of these major types can be broken down into specific styles. Incandescents' major styles are the medium base style, which most people are familiar with (the household kind), and the "par" style, which are used for spot lights and flood lights. Low voltage lighting, such as "track" lights are also in the incandescent family.

Fluorescent lamps come in many different styles and types also. Cool white, warm white, daylight, and deluxe cool white are just a few of the styles. These styles are different from one another mainly in color rendition, which will be discussed later. Fluorescent lamps come in energy saving types as well as high output (increased light output) types, with each types coming in different "color" styles as well. The fluorescent family is quite extensive and must be reviewed constantly by the design engineer due to constant additions by the lamp manufacturers.

High intensity discharge (HID) lamps come in three major types, with each type having characteristics completely separate from the others. These types are mercury vapor, metal halide, and high pressure sodium

(HPS). The primary differences between these types of HID lamps are their efficiencies and their color renditions, both of which will be explained in the following discussions.

When the design engineer selects a lighting source type, there are a number of topics which must be considered. These topics include source efficiency, color rendition criteria, and switching time.

Efficiency. Table 2.5 shows a comparison of the different sources' efficiency ratings. This table is similar to one presented in the AFIT School of Engineering and Services classroom handouts (25). The reader should note the units of the ratings, since the efficiency of a lighting source is determined by the lumen output per wattage input. A lumen in simple terms can be considered the unit quantity of light put out by the lighting source.

The reader should note from Table 2.5 that the incandescent source has the lowest efficiency while the HPS source has highest, and that the three types of HID sources have very different efficiency ratings. Unfortunately, the design engineer cannot choose a light source strictly for efficiency's sake. The high pressure sodium source may have the highest efficiency rating, but it has very poor color rendition and switching characteristics which make it far from the optimal source in most interior lighting cases.

Table 2.5 -- Lamp Efficiencies

SOURCE	LUMENS/WATT
Incandescent	
General Service	21
Extended Service	15
Fluorescent	
Cool White	78
White	80
Warm White	80
High Intensity Discharge	
Mercury	
Clear	46
Phosphor	52
Metal Halide	
Clear	70
Phosphor	90
High Pressure Sodium	125

Color Rendition. Most people associate the "true" color of an object to how it looks in sunlight. Because of this, light source manufacturers have set sunlight "coloration" as a standard to be compared against when stating the color rendition of any given light source. The chart in Table 2.6 is similar to one of General Electric's comparison charts from a Light and Color brochure (24). This chart rates the different types of sources to true sunlight from poor to excellent, and also shows what colors the sources emphasize or "grey" (de-emphasize). Table 2.6 indicates that the fluorescent sources are best at simulating true sunlight, and the high pressure sodium source (HPS) are worst.

Table 2.6 -- Lamp Color Rendition Chart

	Incandescent	High Intensity Discharge		
Lamp Names	Filament	Mercury	Metal Halide	HPS
Lumens/Watt	Low	Medium	High	High
Lamp appearance effect on neutral surfaces	Yellowish white	Greenish blue-white	Greenish white	Yellowish
Effect on "atmosphere"	Warm	Very cool, Greenish	Moderately cool, Greenish	Warm, Yellowish
Colors Strengthened	Red Orange Yellow	Yellow Green Blue	Yellow Green Blue	Yellow Orange Green
Colors Greyed	Blue	Red Orange	Red	Red Blue
Effect on Complexions	Ruddiest	Greenish	Greyed	Yellowish
Remarks	Good color rendition	Very poor color rendition	Color acceptance similar to CW fluorescent	Color acceptance approaches that of WW fluorescent

	Fluorescent			
Lamp Names	Cool White	Warm White	Daylight	White
Lumens/Watt	High	High	Medium-High	High
Lamp appearance effect on neutral surfaces	White	Yellowish white	Bluish white	Pale Yellowish white
Effect on "atmosphere"	Neutral to moderately cool	Warm	Very Cool	Moderately warm
Colors Strengthened	Orange Yellow Blue	Orange Yellow	Green Blue	Orange Yellow
Colors Greyed	Red	Red Green Blue	Red Orange	Red Green Blue
Effect on Complexions	Pale Pink	Sallow	Greyed	Pale
Remarks	Blends with natural daylight Good color acceptance	Blends with incandescent light; simulates natural daylight	Usually replaceable with CW	Usually replaceable with CW or WW

Switching Time. Start-up time (time from when the switch is turned on to when the light comes on), and restart time (switch and light turned off and then back on), are also important factors the design engineer has to consider. For incandescent and fluorescent sources, the start-up and restart times are considered instantaneous; whereas HID sources increase in brightness slowly until they reach their "peak" operating temperature where they remain until turned off. Once turned off, the HID sources require a cool down time before they can be restarted. According to the specific lamp, this "peak" temperature time and restart time could be as short as 30 seconds or as long as 10 minutes. These times make HID sources less than inviting when the designer wants to control the lighting system with an energy management control system (EMCS), or in other areas where the lights might get turned off and on frequently.

Typical Uses. As the reader can see, there are advantages and disadvantages to every type of lighting source. The design engineer must be very careful when choosing the light source type to ensure that the efficiency, the color rendition, and the switching time are compatible with the area being designed. Table 2.7 gives examples of where each major light source type is used.

Light sources (lamps) for the most part, do not have built in directional control to enable them to shine the

Table 2.7 -- Typical Use Areas

SOURCE TYPE	TYPICAL AREAS
Incandescent	Closets Entry Ways Specialty Lighting
Fluorescent	Offices Conference Rooms Hallways
HID	High Bay Areas Warehouses Hangers

light in a certain direction or spread the light out over a given area. Because of this, these sources must be put in enclosures or "fixtures" to control the direction and distribution of the light. Each type of light source is available in a number of different styles of fixture housings, each of which will distribute the light a little differently. The design engineer, once the source type is chosen, must then evaluate distribution criteria to determine which fixture to use.

Fixture Types. There are three main items of concern when choosing a fixture type. Aesthetics is the first major concern in choosing a fixture. Most people would consider a bare bulb fluorescent fixture in a newly constructed office very unattractive. Common sense must rule in the choice. When a fixture is hung below a ceiling, consideration should be given to having the

fixture provide "up-light" (allowing light to come out of the top of the fixture) to avoid a dark dingy looking space above a work area which will, in most cases, detract from the aesthetics of the area. A fixture's distribution type can be determined by looking at Table 2.8.

Aesthetics of an entire building can be enhanced if the design engineer tries to standardize the fixtures used. Conversely, in very special areas, a totally different type of fixture could be used to "call attention" to the area. Aesthetics of the fixture and the given area, though important, are not the only items that the design engineer must consider when choosing a fixture type. The second item of importance, which is closely related to a room's cleanliness factor, is how "dirty" a fixture is allowed to become before cleaning occurs.

The construction type of a fixture will determine how dirty conditions will affect the fixture's ability to distribute light. The IES Lighting Handbook (14) assigns one of five categories to fixtures according to how "open" they are to atmosphere. Table 2.9 is similar to Figure 9-2 of the IES Lighting Handbook.

The more open a fixture's reflective surfaces are to the atmosphere, the more likely it is for the surfaces to become dirty. Maintenance Category I of Table 2.9 indicates a completely open fixture. An example of this type would be a bare bulb fluorescent "shop-light" type of

Table 2.8 -- Luminaire Distribution Types

DISTRIBUTION TYPE	% UP	% DOWN
Indirect	90-100	0-10
Semi-indirect	60-90	10-40
Direct-indirect	40-60	40-60
Semi-direct	10-40	60-90
Direct	0-10	90-100

Table 2.9 -- Luminaire Maintenance Categories

Maintenance Category	Top Enclosure	Bottom Enclosure
I	1. None	1. None
II	1. None 2. Transparent with 15% or more uplight through apertures 3. Translucent with 15% or more uplight through apertures 4. Opaque with 15% or more uplight through apertures	1. None 2. Louvers or baffles
III	1. Transparent with less than 15% upward light through apertures 2. Translucent with less than 15% upward light through apertures 3. Opaque with less than 15% uplight through apertures	1. None 2. Louvers or baffles
IV	1. Transparent unapertured 2. Translucent unapertured 3. Opaque unapertured	1. None 2. Louvers
V	1. Transparent unapertured 2. Translucent unapertured 3. Opaque unapertured	1. Transparent unapertured 2. Translucent unapertured
VI	1. None 2. Transparent unapertured 3. Translucent unapertured 4. Opaque unapertured	1. Transparent unapertured 2. Translucent unapertured 3. Opaque unapertured

fixture. Maintenance Category VI of Table 2.9 indicates a totally enclosed fixture, similar to a fluorescent fixture that is flush mounted in a suspended ceiling.

Once this maintenance category is known, it can be combined with the previously discussed room cleanliness factors (Table 2.4) and fixture distribution type (Table 2.8) to determine a total light loss factor (LLF), which will be discussed further in the calculations section. Fixture dirt will not only detract from aesthetics of the fixture chosen, but will also effect the distribution capabilities of the fixture. This fixture distribution, is the third and last major item that the design engineer must consider when choosing a fixture type.

A fixture's distribution capabilities can be assessed through the understanding of a spacing-to-mounting height (S/MH) ratio. Each fixture is given a S/MH ratio by its manufacturer. S/MH ratios tell the design engineer how far apart two fixtures can be placed. Placing the fixtures further apart then what this ratio allows would result in "dark" spots in certain areas on the working surface. Figure 2.2 shows this pictorially.

In Figure 2.2, the distance between the light fixtures (d) is determined by:

$$d = (S/MH)(h) \qquad (2.3)$$

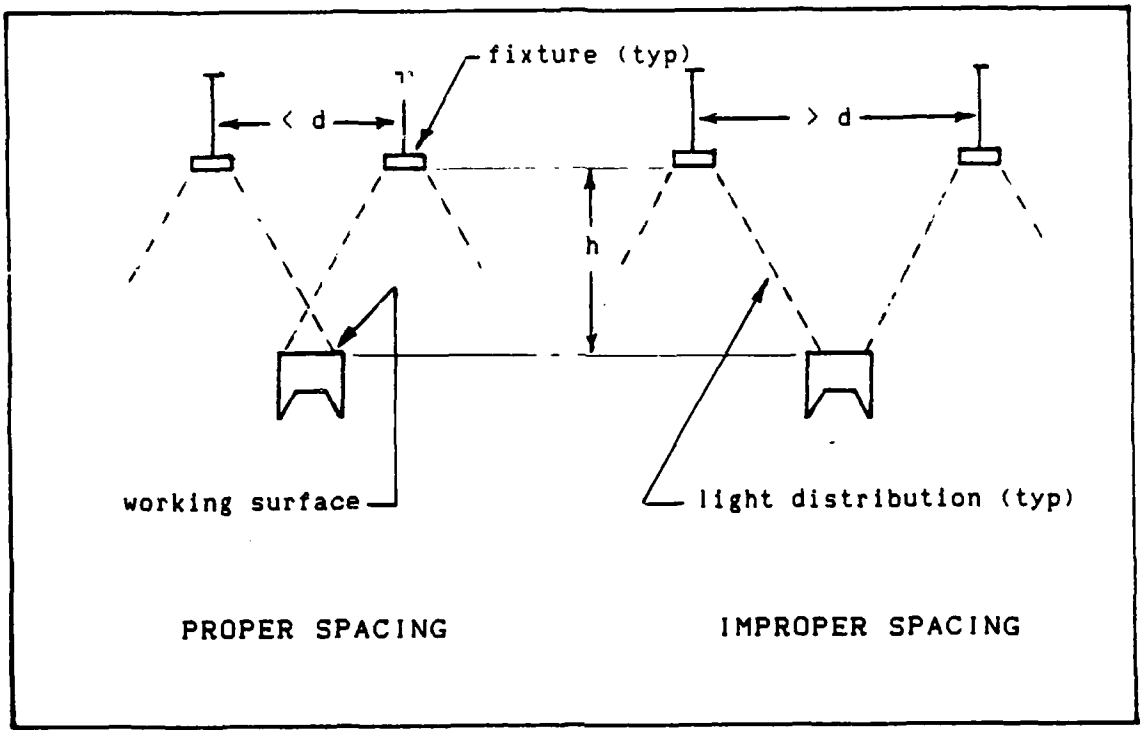


Figure 2.2 -- Luminaire Spacing

where

d = the distance between fixtures (center to center),

S/MH = spacing-to-mounting height ratio, and

h = the mounting height of the fixture (bottom).

One factor that might not be obvious is that the S/MH is directly related to the distribution pattern (spread) of the given fixture. If the design engineer picks a different fixture with a different distribution pattern, and a different S/MH ratio, the maximum distance between the fixtures will be different. Note also that the fixture separation distance (d) is a function of the mounting

height. Thus if the design engineer has the ability to vary the mounting height of the fixtures, as in a high bay area, the fixture spacing can be adjusted.

Unfortunately, there are limits to how much "spread" a given fixture can produce. As an example, for fluorescent troffers (recessed fixtures in suspended ceilings) an average S/MH ratio is 1.3, and a high S/MH ratio is 1.7. This means that average fluorescent troffers (in a 9 foot ceiling) would be spaced a maximum of 11.7 feet away from each other (15.3 feet for the high S/MH). This is true no matter what the intensity (amount) of light the fixture puts out. Although a more thorough explanation will be given later in the calculation section, it is important to note here that the amount of light each fixture puts out will determine how many fixtures are needed in an area. If the S/MH ratio indicates that the given number of lights in an area are too far apart to light the area effectively (no "dark spots"), then the light output of the fixtures must be reduced to increase the number of fixtures in the room. This will allow better spacing of the fixtures. Again, using fluorescent troffers as an example, one way to reduce the light output of a fixture is to reduce the number of lamps in the fixture. A four tube fixture will give off twice as much light as will a two tube fixture. This example illustrates the need for the design engineer to

select fixtures with the proper amount of light output to use for each given job.

Lamp and Ballast Types. The amount of light that any given fixture can give out is only dependent upon the type and number of lamps that it can hold. Incandescent type fixtures normally hold single lamps as do all high intensity discharge (HID) type fixtures. In these fixtures, the intensity of light is adjusted by increasing or decreasing the lumen output of the lamp itself. Remember, a "lumen" is the unit quantity of light given off by a lamp. Fluorescent type fixtures can hold anywhere from one lamp up to as many as eight lamps, with normal quantities being one to four lamps. In most cases, the lumen intensity of fluorescent fixtures is adjusted by the number of lamps used in the fixture.

No matter what type of light source a lamp is, the primary rating of the lamp will be by wattage, and not by lumen output. Fortunately, within source types, an increase in the wattage rating will indicate an increase in lumen output rating as well. Table 2.10 gives a few typical wattage lamps and their associated lumen ratings for the major source types.

Please note that two wattage lamps are shown for both the four foot and eight foot fluorescent lamps. In both cases the lower wattage lamps are considered "energy

Table 2.10 -- Lamp Wattage and Lumen Ratings

SOURCE TYPE	WATTAGE RATING	INITIAL LUMENS	MAINTAINED LUMENS
Incandescent			
(general duty)	75	1190	-
	100	1750	-
	150	2880	-
Fluorescent			
4 foot	35	2850	2510
	40	3150	2770
8 foot	95	8500	7395
	110	9200	8005
HID			
Mercury Vapor	250	12100	10400
	400	22500	19100
Metal Halide	250	20500	17000
	400	34000	26500
HPS	250	27500	24750
	400	50000	45000

saving" type lamps. (These types of lamps should not be mixed and matched with normal lamps to increase or decrease a fixtures light output rating).

The reader should notice on Table 2.10 that there are two listings for lumen output for most lamps. One is the initial lumen output, the other is the maintained lumen output. The difference between these two ratings is a factor of time. As with almost anything, a lamp will perform better when it is new than when it is used. Some manufacturers call the maintained rating a "40%" rating, meaning that after 40 percent of the life of the lamp, the

lumen output has "settled down" to this amount of output. Fortunately, once this lower output rating is reached, the lamp continues to output close to this amount until it decides to "die." A good heuristic for a lamp's maintained lumen output is 85% of the lamp's initial lumen rating. This percentage, presented in decimal form (.85 for the heuristic or default value) is called the lamp lumen depreciation (LLD), and will be used in the calculation section to figure out the total light loss factor of a lighting design. Of course, if the initial and maintained lumen ratings are given by the manufacturer, an actual percentage can be calculated and used for the LLD in the final design calculations.

Although little will be written about the topic of ballasts, it is important to note that all fluorescent and HID lamps require ballasts to work. In most cases, once the lamp is chosen, the associated ballast can be determined. Ballasts, especially on HID type lamps are not interchangeable. Normal and energy saving fluorescent ballasts are available, but the design engineer must be careful when using energy saving ballasts with normal lamps because many types will not handle the additional lamp wattage. The main reason to note the specific ballast used, in all cases, is that the ballast will consume energy. This energy consumption must be known to properly

figure out both the power requirements of the total lighting system and the life cycle costing of the system.

Summary. Luminaire information requirements necessary to perform proper lighting designs are the light source type, with major types being incandescent, fluorescent, and high intensity discharge (HID); the light enclosure or fixture characteristics including both the spacing-to-mounting height (S/MH) ratio and the luminaire (fixture) category; and the lumen rating of the lamp or lamps being used, along with the associated lumen depreciation rating. This luminaire information along with the previously discussed room information will provide all the necessary information to calculate the number of fixtures necessary to light a room to a proper level. Chart 2.2 will list the luminaire information chosen to expand Chart 2.1's room information and to be used by the examples placed in the Calculation Section.

Chart 2.2 -- Luminaire Information

Data		Source
Source Type:	Fluorescent	Chosen, Table 2.7
Fixture Data:		
Distribution Type:	Direct	Table 2.8
Maint. Category:	V	Chosen, Table 2.9
Lamp Data:		Chosen, Table 2.10
Wattage:	40 watts	
Initial Lumens:	3150	
Maintained Lumens:	2770	

Calculations

Purpose. As stated earlier, the ultimate purpose of the calculation stage is to determine the number of luminaires required to light the area of interest. This section will discuss what calculations are necessary to determine that number. Along with this, this section will explain how the information gathered on the room, and the information gathered on the luminaire are used in those calculations.

The actual calculation stage can be split into five steps. The first step will determine the total light loss factor (LLF). The second step will determine the coefficient of utilization (CU) value. The third step will use the LLF and the CU value to determine the total lumens required (TLR) in the given area. The fourth step takes the TLR and calculates the optimum number of luminaires required for the area. The fifth step will use the spacing-to-mounting (S/MH) ratio to give the design engineer help in determining a proper layout for the area, by calculating maximum luminaire-to-luminaire spacing dimensions.

Light Loss Factor. To determine the total light loss factor (LLF), the information gathered for both the room and the fixture will be used. The room cavity ratios (RCR's), the room's dirt condition (Table 2.4), and cleaning cycle time will be needed from the room information; while the luminaire category (Table 2.9), the

luminaire distribution type (Table 2.8), and the lamp lumen depreciation factor (LLD) (in decimal form) will be needed from the luminaire information. The basic formula for the total LLF is:

$$LLF = (LLD)(LDD)(RSDD) \qquad (2.4)$$

where

LLD = the lamp lumen depreciation,

LDD = the luminaire dirt depreciation, and

RSDD = the room surface depreciation

The LLD is determined as discussed in the previous section. Putting those words into a formula results with:

$$LLD = \text{maintained lumens} / \text{initial lumens} \qquad (2.5)$$

where the initial and maintained lumens are obtained from the lamp manufacturer's data. A default value for LLD is 0.85 and can be used in place of the calculated LLD if the maintained lumens of the lamp is not known.

Example 2.3

Purpose: Compute a Lamp Lumen Depreciation factor.

From Chart 2.2:

Initial lamp lumens:	3150 lumens
Maintained lamp lumens:	2770 lumens

$$LLD = 2770 / 3150 = \underline{0.879}$$

Next the luminaire dirt depreciation (LLD) factor must be determined. The LDD is found by using the room's cleaning cycle time (in months), and the luminaire's maintenance category to find the factor given on the correct chart shown in Figure 2.3. Figure 2.3 is a reproduction of Figure 9-5 of the IES Lighting Handbook (14).

The LDD can also be figured by using the luminaire maintenance category and the room's dirt condition, finding the proper constants A and B from Table 2.11 (Figure 9-6 of the IES Lighting Handbook (14)), and solving the equation:

$$LDD = e^{-A(t^B)} \qquad (2.6)$$

where

t = time in years (decimal form)

Example 2.4

Purpose: To Determine a LLD using both Figure 2.3 and Table 2.11 with Equation (2.6).

From Chart 2.1:

Room Dirt Condition:	Clean
Cleaning Cycle:	18 months (1.5 years)

From Chart 2.2:

Maintenance Category:	V

Using Figure 2.3:

LLD = <u>0.85</u>

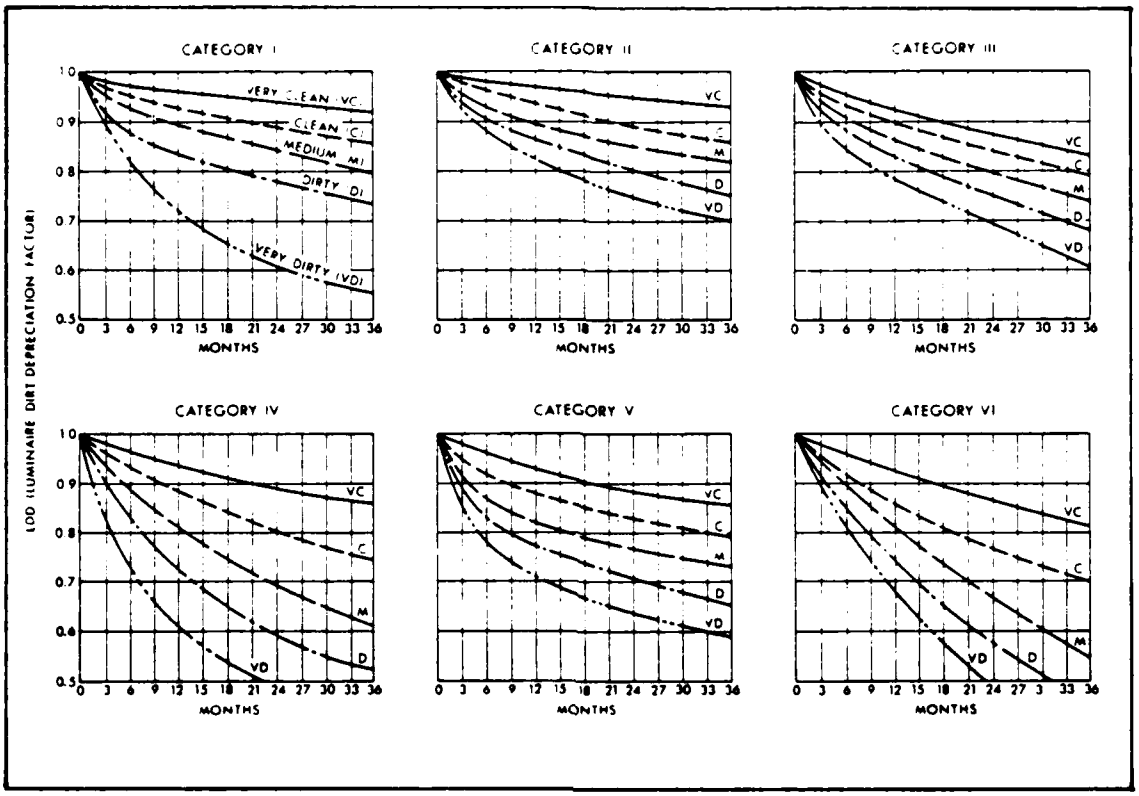


Figure 2.3 -- Luminaire Dirt Depreciation Factor

Table 2.11 -- Luminaire Dirt Depreciation Constants

Luminaire Maintenance Category	B	A				
		Very Clean	Clean	Medium	Dirty	Very Dirty
I	.69	.038	.038	.111	.162	.301
II	.62	.033	.068	.102	.147	.188
III	.70	.079	.106	.143	.184	.236
IV	.72	.070	.131	.216	.314	.452
V	.53	.078	.128	.190	.249	.321
VI	.88	.076	.145	.218	.284	.396

Example 2.4 continued

Using Table 2.11 with Equation (2.6):

From table 2.11:

$$A = 0.128$$
$$B = 0.53$$

From Equation (2.6):

$$LDD = e^{-0.128(1.5\hat{}0.53)}$$
$$= \underline{0.853}$$

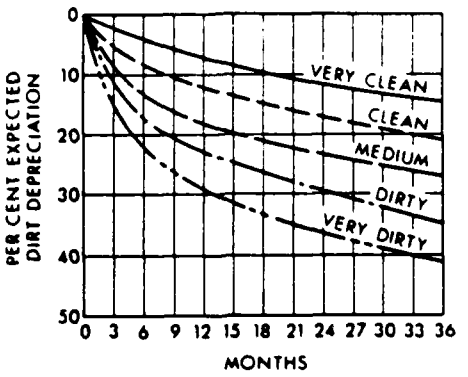
The last item in Equation (2.4) that must be determined prior to calculating the LLF is the room surface depreciation (RSDD) factor. The RSDD is determined by using the room dirt condition and the cleaning cycle time to find a "percent expected dirt depreciation factor" from the graph in Figure 2.4. Using this factor, along with the luminaire distribution type, and the room cavity ratio (RCR), the proper value for the RSDD is determined from the table part of Figure 2.4. Figure 2.4 is a copy of Figure 9-7 of the IES Lighting Handbook (14).

Example 2.5

Purpose: To calculate a room surface dirt depreciation (RSDD) factor

From Chart 2.1

RCR:	1.375
Room Dirt Condition:	Clean
Cleaning Cycle:	18 months



	Luminaire Distribution Type																			
	Direct				Semi-Direct				Direct-Indirect				Semi-Indirect				Indirect			
Per Cent Expected Dirt Depreciation	10	20	30	40	10	20	30	40	10	20	30	40	10	20	30	40	10	20	30	40
Room Cavity Ratio																				
1	98	96	94	92	97	92	89	84	94	87	80	76	94	87	80	73	90	80	70	60
2	98	96	94	92	96	92	88	83	94	87	80	75	94	87	79	72	90	80	69	59
3	98	95	93	90	96	91	87	82	94	86	79	74	94	86	78	71	90	79	68	58
4	97	95	92	90	95	90	85	80	94	86	79	73	94	86	78	70	89	78	67	56
5	97	94	91	89	94	90	84	79	93	86	78	72	93	86	77	69	89	78	66	55
6	97	94	91	88	94	89	83	78	93	85	78	71	93	85	76	68	89	77	66	54
7	97	94	90	87	93	88	82	77	93	84	77	70	93	84	76	68	89	76	65	53
8	96	93	89	86	93	87	81	75	93	84	76	69	93	84	76	68	88	76	64	52
9	96	92	88	85	93	87	80	74	93	84	76	68	93	84	75	67	88	75	63	51
10	96	92	87	83	93	86	79	72	93	84	75	67	92	83	75	67	88	75	62	50

Figure 2.4 -- RSDD Factors

Example 2.5 continued

From Chart 2.2:

Maintenance Category: V
Distribution Type: Direct

From graph in Figure 2.4:

% expected DD = 15

Example 2.5 continued

From table in Figure 2.4:

For a "Direct" luminaire type:		Table Reading
with % expected DD = 10		
and RCR = 1		$RSDD_1 = 0.98$
and RCR = 2		$RSDD_2 = 0.98$
extrapolate for RCR = 1.375		$RSDD_A = \underline{0.98}$
with % expected DD = 20		
and RCR = 1		$RSDD_3 = 0.96$
and RCR = 2		$RSDD_4 = 0.96$
extrapolate for RCR = 1.375		$RSDD_B = \underline{0.96}$
for % expected DD = 15		
and RCR = 1.375		
extrapolate between $RSDD_A$ and $RSDD_B$:		
final computed RSDD =		$\underline{0.97}$

These factors, the LLD, the LDD, and the RSDD when plugged into Equation (2.4) will determine a factor for the total light loss factor (LLF) for the given room and luminaire combination. This factor will be used in step 3 of the calculation stage to determine the total number of lumens required (TLR).

It is important to note that this factor (LLF) is used to determine the "maintained" lumen level of the area. All

of the individual factors that go into calculating the LLF represent "depreciation" amounts, necessary because of dirty room conditions that happen over a period of time.

Example 2.6

Purpose: To combine the factors calculated in Examples 2.3, 2.4, and 2.5 into a total LLF.

From Example 2.3

$$LLD = 0.879$$

From Example 2.4

$$LDD = 0.853$$

From Example 2.5

$$RSDD = 0.97$$

From Equation (2.4)

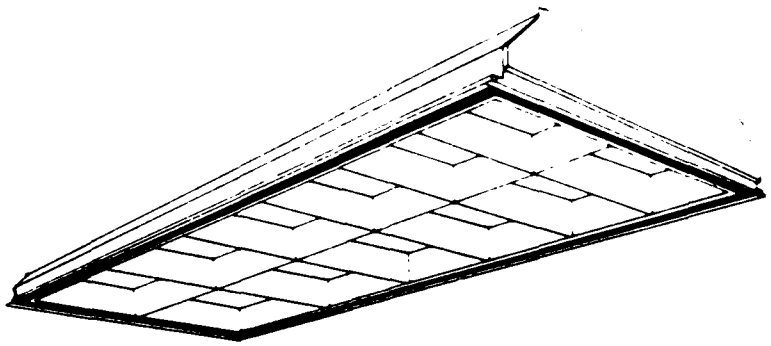
$$LLF = (0.879)(0.853)(0.97)$$
$$= \underline{0.727}$$

Coefficient of Utilization. Chapter I mentioned that the method used in this project to perform lighting design is the Zonal Cavity Method. This method, developed by the Illumination Engineering Society (IES), uses the coefficient of utilization (CU) as a factor that combines the room cavity ratios (RCR's) and the surface reflectance values, described in the room information section of this chapter, into one number that can be used in Step 3 of the

calculation stage to calculate the total number of lumens needed to light a room. The figuring of this CU value is the second step in the actual calculation stage of lighting design. This CU value effectively indicates how the room "uses" the light that is given off and distributed by the luminaire.

Each luminaire's manufacturer's data will have a CU photometric chart published with it. Figure 2.5 pictures a luminaire and its associated CU photometric chart (Lithonia Model 2PM4-240 (26)). This chart will be used along with the effective reflectance values, P_{cc} (ceiling), P_{w} (wall), and P_{fc} (floor), and the room cavity ratio (RCR) to determine exactly what CU number to use.

During inspection of the photometric chart, the reader should notice that the floor reflectance is the only factor that does not have multiple choices associated with it. All other factors do have multiple choices, and the actual CU value can be mathematically extrapolated for factors that are not shown. As an example, an effective ceiling reflectance of 75% can be linearly extrapolated from between the 70% and the 80% CU values given in the chart. When it is necessary to determine a CU factor for floor reflectances other than 20%, Table 2.12 (Figure 9-13 from the IES Lighting Handbook (14)) must be used to obtain a constant to multiply the CU factor obtained from



PHOTOMETRICS

COEFFICIENTS OF UTILIZATION **ZONAL CAVITY**

Ptc	20%														
Pcc	80%				70%				50%			30%			
Pw	70%	50%	30%	10%	70%	50%	30%	10%	50%	30%	10%	50%	30%	10%	
1	77	74	72	70	75	73	71	69	70	68	67	67	66	65	
2	71	67	63	60	70	65	62	59	63	60	58	61	59	57	
3	66	60	55	52	64	59	55	51	57	53	50	55	52	49	
4	61	54	49	45	59	53	48	44	51	47	44	50	46	43	
5	56	48	42	38	54	47	42	38	46	41	38	44	40	37	
6	51	43	37	33	50	42	37	33	41	36	33	40	36	33	
7	47	38	33	29	46	38	33	29	37	32	29	36	32	28	
8	43	34	29	25	42	34	29	25	33	28	25	32	28	24	
9	40	31	25	21	39	30	25	21	29	25	21	29	24	21	
10	37	28	22	19	36	27	22	19	27	22	19	26	22	18	

*Standard ballast, F40T12/CW lamps (3200 lumens)
Spacing criteria: ∥ = 1.2 x mounting height
⊥ = 1.6 x mounting height

Figure 2.5 -- Fixture and CU Chart

photometric chart by. Extrapolation from the tables in Table 2.12 is also possible.

Once the CU value is found, it is used in Step 3 along with the light loss factor to help determine the total amount of lumens necessary to light an area to a predetermined level.

Table 2.12 -- Floor Reflectance Multiplying Factors

Effective Ceiling Cavity Reflectance ρ_{cc}	80				70				50			30			10		
Wall Reflectance ρ_w	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10
For 30 Per Cent Effective Floor Cavity Reflectance (20 Per Cent = 1.00)																	
Room Cavity Ratio																	
1	1.092	1.082	1.075	1.068	1.077	1.070	1.064	1.059	1.049	1.044	1.040	1.028	1.026	1.023	1.012	1.010	1.008
2	1.079	1.066	1.055	1.047	1.068	1.057	1.048	1.039	1.041	1.033	1.027	1.026	1.021	1.017	1.013	1.010	1.006
3	1.070	1.054	1.042	1.033	1.061	1.048	1.037	1.028	1.034	1.027	1.020	1.024	1.017	1.012	1.014	1.009	1.005
4	1.062	1.045	1.033	1.024	1.055	1.040	1.029	1.021	1.030	1.022	1.015	1.022	1.015	1.010	1.014	1.009	1.004
5	1.056	1.038	1.026	1.018	1.050	1.034	1.024	1.015	1.027	1.018	1.012	1.020	1.013	1.008	1.014	1.009	1.004
6	1.052	1.033	1.021	1.014	1.047	1.030	1.020	1.012	1.024	1.015	1.009	1.019	1.012	1.006	1.014	1.008	1.003
7	1.047	1.029	1.018	1.011	1.043	1.026	1.017	1.009	1.022	1.013	1.007	1.018	1.010	1.005	1.014	1.008	1.003
8	1.044	1.026	1.015	1.009	1.040	1.024	1.015	1.007	1.020	1.012	1.006	1.017	1.009	1.004	1.013	1.007	1.003
9	1.040	1.024	1.014	1.007	1.037	1.022	1.014	1.006	1.019	1.011	1.005	1.016	1.009	1.004	1.013	1.007	1.002
10	1.037	1.022	1.012	1.006	1.034	1.020	1.012	1.005	1.017	1.010	1.004	1.015	1.009	1.003	1.013	1.007	1.002
For 10 Per Cent Effective Floor Cavity Reflectance (20 Per Cent = 1.00)																	
Room Cavity Ratio																	
1	923	929	935	940	933	939	943	948	956	960	963	973	976	979	989	991	993
2	931	942	950	958	940	949	957	963	962	968	974	976	980	985	988	991	995
3	939	951	961	969	945	957	966	973	967	975	981	978	983	988	988	992	996
4	944	958	969	978	950	963	973	980	972	980	986	980	986	991	987	992	996
5	949	964	976	983	954	968	978	985	975	983	989	981	988	993	987	992	997
6	953	969	980	986	958	972	982	989	977	985	992	982	989	995	987	993	997
7	957	973	983	991	961	975	985	991	979	987	994	983	990	996	987	993	998
8	960	976	986	993	963	977	987	993	981	988	995	984	991	997	987	994	998
9	963	978	987	994	965	979	989	994	983	990	996	985	992	998	988	994	999
10	965	980	989	995	967	981	990	995	984	991	997	986	993	998	988	994	999
For 0 Per Cent Effective Floor Cavity Reflectance (20 Per Cent = 1.00)																	
Room Cavity Ratio																	
1	859	870	879	886	873	884	893	901	916	923	929	948	954	960	979	983	987
2	871	887	903	919	886	902	916	928	926	938	949	954	963	971	978	983	991
3	882	904	915	942	898	918	934	947	936	950	964	958	969	979	976	984	993
4	893	919	941	958	908	930	948	961	945	961	974	961	974	984	975	985	994
5	903	931	953	969	914	939	958	970	951	967	980	964	977	988	975	985	995
6	911	940	961	976	920	945	965	977	955	972	985	966	979	991	975	986	996
7	917	947	967	981	924	950	970	982	959	975	988	968	981	993	975	987	997
8	922	953	971	985	929	955	975	986	963	978	991	970	983	995	976	988	998
9	928	958	975	988	933	959	980	989	966	980	993	971	985	996	976	988	998
10	933	962	979	991	937	963	983	992	969	982	995	973	987	997	977	989	999

Example 2.7

Purpose: To calculation the CU value for Room #1.

From Chart 2.1:

$$RCR = 1.375$$
$$P = 0.78$$
$$P^{cc} = 0.70$$
$$P^{w}_{fc} = 0.21$$

Example 2.7 continued

(note: the RCR is the left most column of Figure 2.5's photometric chart and the chart values are in percent, ie. 77 = 0.77)

		From Figure 2.5:	Table Reading
for	$P_{fc} = 0.20$, $P^{cc}_{w} = 0.70$		
		RCR = 1	$CU_1 = 0.75$
		RCR = 2	$CU_2 = 0.70$
extrapolate for:		RCR = 1.375	$CU_A = \underline{0.731}$
for	$P_{fc} = 0.20$, $P^{cc}_{w} = 0.80$		
		RCR = 1	$CU_3 = 0.77$
		RCR = 2	$CU_4 = 0.71$
extrapolate for:		RCR = 1.375	$CU_B = \underline{0.748}$

extrapolate between CU_A and CU_B:

for $P_{cc} = 0.78$ $\quad CU_C = \underline{0.745}$

		From Figure 2.12:	Table Reading
for	$P_{fc} = 0.20$, $P^{cc}_{w} = 0.70$		
		RCR = 1	$K_1 = 1.077$
		RCR = 2	$K_2 = 1.068$
extrapolate for:		RCR = 1.375	$K_A = \underline{1.074}$
for	$P_{fc} = 0.20$, $P^{cc}_{w} = 0.80$		

Example 2.7 continued

	RCR = 1		K_3 = 1.092
	RCR = 2		K_4 = 1.079
extrapolate for:	RCR = 1.375		K_B = <u>1.087</u>

extrapolate between K_A and K_B:

for P_{cc} = 0.78 K_C = <u>1.084</u>

extrapolate between K_C and 1.0:

for P_{fc} = 0.21 K_D = <u>1.008</u>

To calculate a final CU value:

$$CU = CU_C * K_D$$

Thus:

$$CU = (0.745)(1.008)$$
$$= \underline{0.751}$$

<u>Total Lumens Required.</u> The third step in the calculation stage of lighting design is to calculate the total lumens required (TLR) to light a given area to a predetermined level. As mentioned in the previous sections, a lumen is defined as the quantity of light put out by a given light source. How much of this "light" is required in a given area is determined by the following formula:

$$TLR = (FC)(A) / (LLF)(CU) \qquad (2.7)$$

where

TLR = the total lumens required,

FC = the footcandle level for the room,

A = the floor area of the room,

LLF = the light loss factor, and

CU = the CU value

As mentioned in the light loss factor discussion, Equation (2.7) will calculate total "maintained" lumens required. To calculate total "initial" lumens required, the LLF factor is left out of Equation (2.7). Knowing the initial lumens required to light an area can help the design engineer check the designed area immediately after construction is completed to verify the lighting system installation.

Once the total lumens required (TLR) factor is determined, it must be combined with the initial lamp lumens given off by the specific lamp (Table 2.10) being used, and the number of lamps per luminaire to determine the total number of luminaires required to light a given area.

Example 2.8

Purpose: Calculate the total lumens required (TLR).

From Chart 2.1:

Required FC = 50 fc_2
Area = 1600 ft^2

Example 2.8 continued

From Example 2.6:

LLF = 0.727

From Example 2.7:

CU = 0.751

From Equation (2.6):

TLR = (50)(1600) / (0.751)(0.727)
= 146526 lumens

Number of Luminaires Required. Determining the number of luminaires required in a given area is the fourth step in the calculation stage of lighting design, and as stated before, is the main objective of the calculation stage of lighting design. To determine the total number of luminaires required, the following equation should be used:

$$\text{number of fixtures} = TLR / (ILL)(L/F) \qquad (2.8)$$

where

TLR = total lumens required,

ILL = initial lamp lumens, and

L/F = number of lamps per fixture

The initial lamp lumens will be extracted from the manufacturer's data on the specific lamp being used (Table 2.10), and the number of lamps per fixture will be determined by the amount of lamps the exact luminaire chosen by the design engineer uses.

Example 2.9

Purpose: To calculate the total number of fixtures required in Room #1.

From Chart 2.2:

Lamp Style: 40 watt fluorescent
Initial lumens (ILL): 3050 lumens/lamp

From Example 2.8:

TLR = 146526 lumens

From Figure 2.5 (which is a two lamp fixture):

L/F = 2

From Equation (2.8):

# of fixtures = (146526) / (3050)(2)
= 24.02 fixtures

Spacing Criteria. The only step left for the design engineer to perform in the calculation stage is the fifth step that calculates the luminaire-to-luminaire spacing criteria for layout purposes. This step has been discussed in some detail in the Luminaire Information Requirements section, and the formula for calculating the spacing between fixtures is given in Equation (2.3). The reader should notice that Figure 2.5 has two S/MH ratios stated. The top ratio is for spacing requirements side-to-side (in this case the four foot dimension of the luminaire). The bottom ratio is for spacing requirements end-to-end (the two foot dimension).

Conclusion

This chapter discussed, in depth, the necessary information requirements needed to perform proper Zonal Cavity Method lighting design calculations, and reviewed the calculations themselves. These calculations complete the first stage of a proper lighting design and are followed by the layout stage and the iteration stage. The layout stage, although outside the scope of this project, is at least started in the calculation stage by the determination of the maximum luminaire-to-luminaire spacing criteria. The iteration stage, involving the reenactment of the calculation stage and the layout stage, helps ensure that there are comparative designs performed. These comparative designs, in turn, will help the design engineer choose the "best" lighting system for the given area.

Chart 2.3 is included to give a total look at all the information requirement areas and all the calculated items that are necessary for a completed calculation stage of interior lighting design. Chart 2.3 will also be used for comparison purposes in Chapter IV, during the program validation sequence.

Chart 2.3 -- Interior Lighting Design Results

Room Information: (Chart 2.1)

Room Use:	Office	FC Required:	50 fc
Room length:	40 ft	Room area:	1600 ft^2
Room width:	40 ft		
Ceiling height:	10 ft	CCR:	0.5
Fixture height:	8 ft	RCR:	1.375
Working height:	2.5 ft	FCR:	0.625
Ceiling color:	Winter White		
Wall color:	Silver Lining		
Floor color:	Crayon Blue		
P_c:	0.83	P_{cc}:	0.78
P^c:	0.70		
P^w_f:	0.20	P_{fc}:	0.21

Room dirt condition: Clean
Cleaning cycle: 18 months

Luminaire Information: (Chart 2.2)

Source type:	Fluorescent
Maintenance category:	V
Distribution type:	Direct
S/MH Ratio:	1.2
Initial lamp lumens:	3150
Maintained lamp lumens:	2770

Calculation Results:

Data		Source
LLD = 0.879		Example 2.3
LDD = 0.853		Example 2.4
RSDD = 0.97		Example 2.5
LLF = 0.727		Example 2.6
Initial CU value:	0.745	Example 2.7
Floor mult. factor:	1.008	Example 2.7
Final CU value:	0.751	Example 2.7
TLR = 146526 lumens		Example 2.8
# of fixtures required:	24	Example 2.9

III. Program Considerations and Development

General

This chapter will present a general discussion of the two major pre-programming considerations and three basic programming considerations that have been identified prior to actually starting the development of the computer program. In addition to this discussion on the pre-programming and the programming considerations, actual program development methods used to satisfy these considerations will be presented.

Pre-programming Considerations

There are two pre-programming areas of consideration in creating this program to comply with the objectives as stated at the end of Chapter I. The first of these is the question of how to make the program work on as many different types of computer systems as possible. The second consideration is that when this program is turned over to the electrical group at the AFIT School of Civil Engineering and Services, how straight forward can this program be made to enable periodic updating and expansion.

The answer to the first consideration's question is to create the program in a computer language that is as universal as possible. This language, for MS-DOS operating systems (which the Wang pc, and the Zenith Z-248, the TeleVideo all operate on) is called BASIC. Although each

computer system has its own actual version of BASIC, the basis for these different versions is the same for all. In other words, although each of the computer systems will have a few "special" commands peculiar to its own system, the majority of the commands that each system will execute are the same. Thus, the program on Interior Lighting Design developed for this project will be programmed in the programming language of BASIC in such a way as to maximize transportability between computer brands.

Fortunately, since BASIC is essentially universal among computer systems, it is also well known by computer programmers, and is fairly easy to learn by those who are not computer experts. This essentially answers to the concern regarding updates and expansion. It is important to make the programming easy to follow and understand. This will be done by ensuring that all variable names are identified, by commenting the programming lines, and by breaking the program into small interdependent parts called subroutines.

Programming Considerations

There are three major programming considerations for the development of this computer program on interior lighting design. These considerations are: 1) "user friendliness"; 2) proper information databases; and 3) meaningful output. "User friendliness" is a term that simply means the program should be easy for the design

engineer to use. Current developments in computer-aided engineering (CAE) encourage "menu" driven programs to make a program more user friendly. With the use of "menus," the user chooses from a preset listing to answer questions posed by the program. Figure 3.1A illustrates a typical non-menu driven program statement that would require manual responses from the user. Figure 3.1B illustrates how Figure 3.1A could be turned into a menu-driven program statement. The non-menu type statement does not give the user any help as to what would be an acceptable or standard answer, whereas the menu-driven statement does give the user help - and answers. The program developed for this thesis effort will be menu-driven.

A menu-driven program, although user friendly, requires a greater amount of stored information than does a non-menu driven program. All of the information that the program needs to "help" the design engineer must be stored where it can be referenced by the program. An extensive set of data will be required to set up proper menus for this program. Program development for this thesis effort will create one set of information data that can be updated or changed by the user. A second set of data will be protected from design engineering changes. This is because some data, such as lamp style data needs periodic updating, whereas other data, such as the effective reflectance tables (Table 2.3), do not need to be updated or changed.

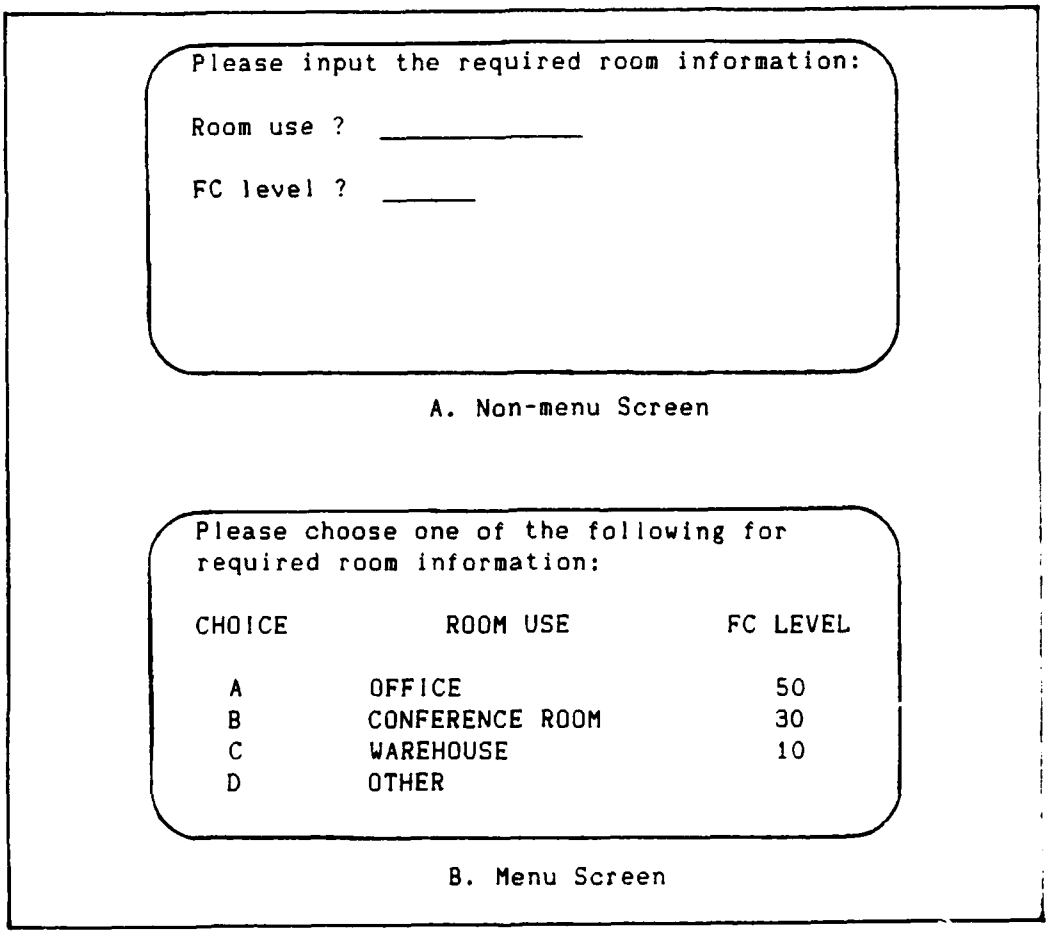


Figure 3.1 -- Menu Screen Comparison

The third primary consideration for this computer program is ensuring meaningful output. One of the best operations a computer performs is "number crunching," but unless the program is selective in choosing which number to give display for the design engineer, the computer is more than capable of displaying a mass of numbers, all of which may oe irrelevant. Thus, this program should give only meaningful output to the design engineer.

Actual Program Development

In the pre-programming section, the two considerations discussed were to make the program work on as many different computers as possible by using a computer language called BASIC, and by using this language, make the program easily expandable. Both of these considerations were taken into account during the actual program development.

The program (to be referenced to as "LIGHT1A" hereafter) has been run on three different computer brands. These brands were the Wang pc (which was the primary objective), the Zenith Z-248, and the TeleVideo XL portable computer. LIGHT1A performed properly on all three brands. The actual BASIC source code for LIGHT1A is given in Appendix A.

In the formulation of LIGHT1A, the overall program was actually split into three sub-programs. The primary reason for this "split" was to stay within the computer memory space allowed by the BASIC language. (BASIC allows only 64 kbytes of memory to be used, no matter what the size of the computer hardware memory available.) The first sub-program is strictly held to a copyright screen, and a main menu which "calls" the other two sub-programs. The second sub-program records the room information and the luminaire information, and performs the actual calculations as described in Chapter II. The third sub-program allows

the design engineer to update the "changeable" data needed in the program, and to produce printouts of these data files enabling the user to keep a hardcopy of them.

Both of the second two sub-programs are split into the interdependent sub-routines mentioned in the previous sections. A listing of these sub-routine titles is given in Appendix B. These sub-routines split the given sub-program into small "logical" elements of program development. As an example, each separate step of the calculation stage is performed in a separate sub-routine. This sub-routine type of set-up will enable future expansion of LIGHT1A by allowing each sub-routine to be copied intact and reused if necessary to perform the same work in another area of application.

Actual Program Usability

In the programming considerations section of this chapter, there were three major considerations discussed. These considerations were using "menus" to make the program user friendly; creating a large amount of stored data, both changeable and unchangeable, to support the menus; and ensuring meaningful output. These considerations were taken into account during program development. The following discussion will describe how these three considerations were built into the program.

During the development of LIGHT1A, the program was set up so that the design engineer could either use "help"

menus (or "tables" as they are referenced in the program) or just answer questions that LIGHT1A asks to input the necessary information requirements. Menus similar to Figure 3.1B are generated to help the user answer the questions on the following areas:

1. Actual room use and required FC level
2. Room surface color and reflectance ratios
3. Room cleanliness factors and cleaning cycle
4. Light source type selection
5. Fixture style
6. Fixture distribution type
7. Fixture maintenance categories
8. Lamp style

Other questions that LIGHT1A asks are preceded by prompts that attempt to help the design engineer understand the question. If the design engineer chooses not to use the menus, LIGHT1A issues sets of questions that the he/she must answer to input the necessary information on the above topics so that the calculations can be performed.

To support the menus described above, a number of data files had to be created to allow LIGHT1A to access the information needed to generate the menus. This was the second area discussed in the programming consideration section. Two types of data files were created in the development of LIGHT1A. The first type can be described as "changeable." This set of data files uses the third sub-

program described in the previous section to allow the design engineer to update the files when necessary. These files include the information needed to create the room use and required FC menu, the room surface color and reflectance ratio menu, the fixture style menu, and the lamp style menu. Except for the room use and required FC menu, the data stored in these menus are the type that supports the design engineer's own design preference since each designer will have his/her own "favorite" colors, fixture styles, and lamp styles. The room use and required FC level menu is generated from data taken from the AFR 88-15 (Table 2.1), and will only need updating if the regulation changes. Along with the ability for the design engineer to change the information that these data files contain, the third sub-program referenced in the previous section allows the design engineer to get a hardcopy of the files through a printer. Appendix C contains a hardcopy listing of the four files described here to be "changeable."

The second type of data file that was created for LIGHT1A is not "changeable". Included in this type of file was the data for the room cleanliness factors menu, the fixture distribution menu, and the fixture maintenance category menu. Also included in this type of data file was the "number charts" that are required to be used in the calculations (Tables 2.3, 2.11, and 2.12, and Figures 2.3

and 2.4). All of this data can be considered constant. In other words, this data is never changed in its use within the Zonal Cavity Method of lighting design.

The last major consideration during the programming stage of the thesis was the aspect of ensuring that the program gives a meaningful output. The best way to do this is to use LIGHT1A to perform lighting design calculations, and then make sure that the numbers generated by the program are accurate. Chapter IV will compare how LIGHT1A's calculations compare to the ones performed in Chapter II. Along with showing the output of the program, Chapter IV will walk through the LIGHT1A's method of requesting information from the design engineer, and will show some of the computer screens generated by LIGHT1A.

IV. Program Validation

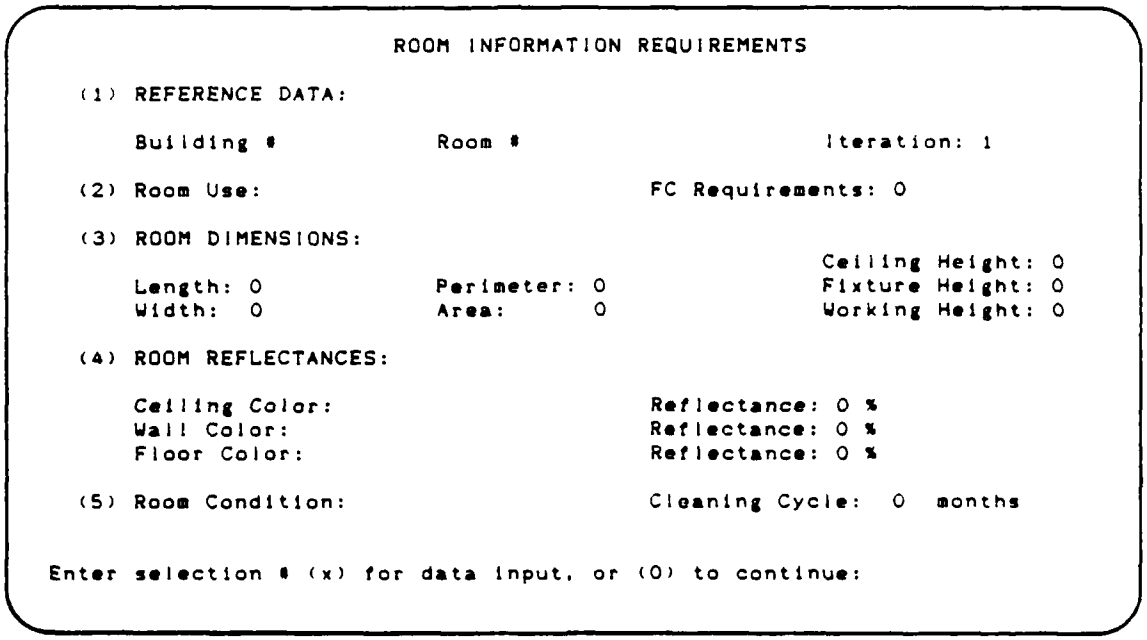
Verification

There is nothing more disturbing then to rely on a piece of equipment, only to find out that it doesn't work properly when you use it. Similarly, a computer program that puts out false calculations is useless. Even more unfortunate, many times, unless the program is checked by another means, the faulty calculations are not caught. Because of this, all new software packages should be verified for usefulness (32:94).

To verify that LIGHT1A performs accurate lighting design calculations, this chapter will quickly walk through the example problem that was used throughout Chapter II using the program. Charts 2.1, 2.2, and 2.3 will be compared to computer generated "screens" throughout this chapter. ("Screen" refers to what is actually shown on the screen of the computer's CRT.) Only specific "screens" needed to illustrate the LIGHT1A's ability will be shown in this chapter. For a complete set of screens that are generated to perform this problem from beginning to end on LIGHT1A, refer to Appendix D.

LIGHT1A's Solution

Chart 2.1 should be referenced for a complete listing of the room information generated for the example problems in Chapter II. Screen 4.1 will be the first working screen



Screen 4.1 -- Initial Room Information Screen

that the program will generate when using the "help" menus of LIGHT1A. At the beginning, this screen will not contain any information concerning the room. To fill in the room information, the design engineer simply enters the number of the item that he/she wishes to complete. For example, to input the Room Use data, the design engineer would enter "2." This would cause the AFR 88-15 tables (Table 2.1) to come up on the screen so that the base engineer may choose a room use and associated FC level requirement. After a choice is made and entered, Screen 4.1 will return to the screen with that chosen information showing in the proper location. This procedure is repeated until all of the room information requirements are entered. Screen 4.2 is the same as Screen 4.1 but with all the room information

```
                    ROOM INFORMATION REQUIREMENTS

(1) REFERENCE DATA:

    Building # None      Room # None                  Iteration: 1

(2) Room Use: General Offices            FC Requirements: 50

(3) ROOM DIMENSIONS:

                                                  Ceiling Height: 10
    Length: 40           Perimeter: 160           Fixture Height: 8
    Width:  40           Area:      1600          Working Height: 2.5

(4) ROOM REFLECTANCES:

    Ceiling Color: Winter White          Reflectance: 83 %
    Wall Color:    Silver Lining         Reflectance: 70 %
    Floor Color:   Crayon Blue           Reflectance: 20 %

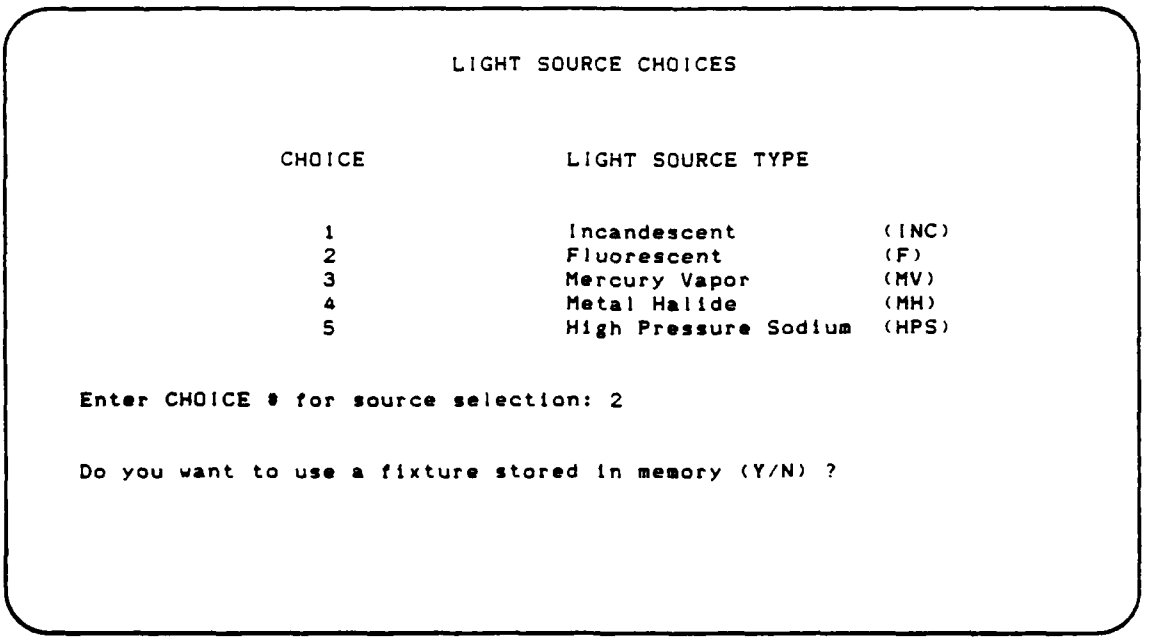
(5) Room Condition: Clean                Cleaning Cycle:  18  months

Enter selection # (x) for data input, or (0) to continue:
```

Screen 4.2 -- Completed Room Information Screen

showing. Note that Screen 4.2 contains the same information as does Chart 2.1 of Chapter II.

Once the room information is completely entered, the design engineer must then choose the type of light source that is wanted. Screen 4.3 indicates the choices, which are similar to those listed in Table 2.5, available. Also, the design engineer is asked if a fixture in memory is wanted. If a fixture in memory <u>is</u> wanted, LIGHT1A generates a menu showing the design engineer what choices are available in the source type that was picked (for example -- fluorescent). The design engineer simply needs to pick one of the fixtures listed, and then a corresponding lamp style, to fulfill the luminaire information requirements of LIGHT1A.



Screen 4.3 -- Light Source Choices Screen

If a fixture in memory is not wanted (as in our case with the example problem), the design engineer must answer a series of questions to tell LIGHT1A what kind of fixture that will be used. After this information is entered, LIGHT1A determines the coefficient of utilization (CU) values that must be entered to perform the calculations, and prompts the base engineer for those values. Screen 4.4 shows the screen that LIGHT1A generates after the fixture information is entered. The reader will notice that the "Fixture File #" and the "Lamp File #" spaces are blank. These two items are only used when fixture and lamp information is taken from memory. Screen 4.4 can be compared to Chart 2.2 and contains all the information pertaining to the luminaire.

```
                    LUMINAIRE INFORMATION REQUIREMENTS

     Building # None          Room # None          Iteration:  1

(1) LUMINAIRE INFORMATION:

     Fixture File #                    S/MH Ratio:              1.2
     Fixture Make:  Lithonia           Maintenance Catagory:    V
     Fixture Model: 2PM4-240           Distribution Type:       5

(2) LAMP INFORMATION:

     Lamp File #                       Lamp Watts:          40
     Lamp Type:  F40                   Initial Lumens:      3150
     Quantity:   2                     Maintained Lumens:   2770

(3) DIFFERENT SOURCE TYPE

Enter selection # (x) for data input, or (0) to continue:
```

Screen 4.4 -- Luminaire Information Screen

After all the room and luminaire information is entered, LIGHT1A performs the lighting design calculations that were performed in Chapter II. Screens 4.5 and 4.6 give the design engineer all the information and calculation results that are pertinent to the lighting design. Table 4.1 is a copy of the hardcopy that LIGHT1A will produce on a printer if the design engineer desires a permanent copy of the results. For ease of comparison, the reader should observe Table 4.1 and Chart 2.3.

The final calculation for the number of fixture number required in this example's room is 24 for both the hand calculations (Chapter II) and the computer calculations (this chapter). The only differences that can be noted are the results for the effective ceiling reflectance (78 by hand verses 76 by computer), and the final CU value (0.751

```
                    FINAL DESIGN CALCULATIONS

Building # None          Room # None                    Iteration:  1

Room Use: General Offices                               FC Required:  50

     CCR =  0.50        Ceiling Reflectance:  83        Effective:    76
     RCR =  1.38        Wall Reflectance:     70
     FCR =  0.63        Floor Reflectance:    20        Effective:    21

Fixture Make: Lithonia          Model # 2PM4-240        2  tube

     Critical PFR : 20                                  S/MH Ratio = 1.2
     CU       PCR : 80          70
     Values   PWR : 70          70                      Total LLF  = 0.727
              RCR :
              ----:-------------------                  Final  CU  = 0.745
              1   : 77          75
              2   : 71          70


Number of Fixtures Required:  23.44

How many fixtures do you want to use ?
```

Screen 4.5 -- First Screen of Calculation Results

```
                    FINAL DESIGN CALCULATIONS

Building # None          Room # None                    Iteration:  1

Room Use: General Offices                               FC Required:  50

Fixture Make: Lithonia          Model # 2PM4-240        2  tube


     LLD =          0.879          Floor Cavity Factor =     1.007
     LDD =          0.853          Final CU Value =          0.745
     RSDD =         0.969
     Total LLF =    0.727          S/MH Ratio =              1.2
                                   Spacing Criteria (ft):    6.6

Initial FC Level:      70          Fixture # Required:      23.44
Maintained FC Level:   51          Fixture # Used:          24


ENTER:
 (1)    To do another iteration of this room
 (2)    To go to Main Menu, clearing all variables
 (3)    To get a hardcopy, and return to this screen
?
```

Screen 4.6 Second Screen of Calculation Results

Table 4.1 -- Hardcopy of Calculation Results

```
                INTERIOR LIGHTING DESIGN PROGRAM OUTPUT

BUILDING # None          ROOM # None              ITERATION:  1

ROOM INFORMATION:

   Use: General Offices                    FC Required:  50

   Length:  40                             Perimeter:    160
   Width:   40                             Area:         1600

   Ceiling Height:  10                     CCR:  0.50
   Fixture Height:  8                      RCR:  1.38
   Working Height:  2.5                    FCR:  0.63

   C. Color: Winter White     Reflectance:  83    Effective:  76
   W. Color: Silver Lining    Reflectance:  70
   F. Color: Crayon Blue      Reflectance:  20    Effective:  21

   Room Condition: Clean                   Cleaning Cycle:  18  months

LUMINAIRE INFORMATION:

   Fixture File #                          Lamp File #
   Fixture Make:  Lithonia                 Lamp Type:  F40
   Fixture Model: 2PM4-240

   S/MH Ratio:              1.2            Lamp Quantity:       2
   Maintenance Category:    V              Initial Lumens:      3150
   Distribution Type:       5              Maintained Lumens:   2770

   Necessary Values from
   Fixture's CU Chart:                     LLD:                 0.879
                                           LDD:                 0.853
   PFR : 20                                RSDD:                0.969
   PCR : 80          70                    Total LLF:           0.727
   PWR : 70          70
   RCR :                                   Floor Cavity Factor: 1.007
   ----:--------------------               Final CU:            0.745
   1   : 77          75
   2   : 71          70

RESULTS:                                   Spacing Criteria (ft):  6.6

   Fixture # Required:   23.44             Initial FC Level:       70
   Fixture # Used:       24                Maintained FC Level:    51
```

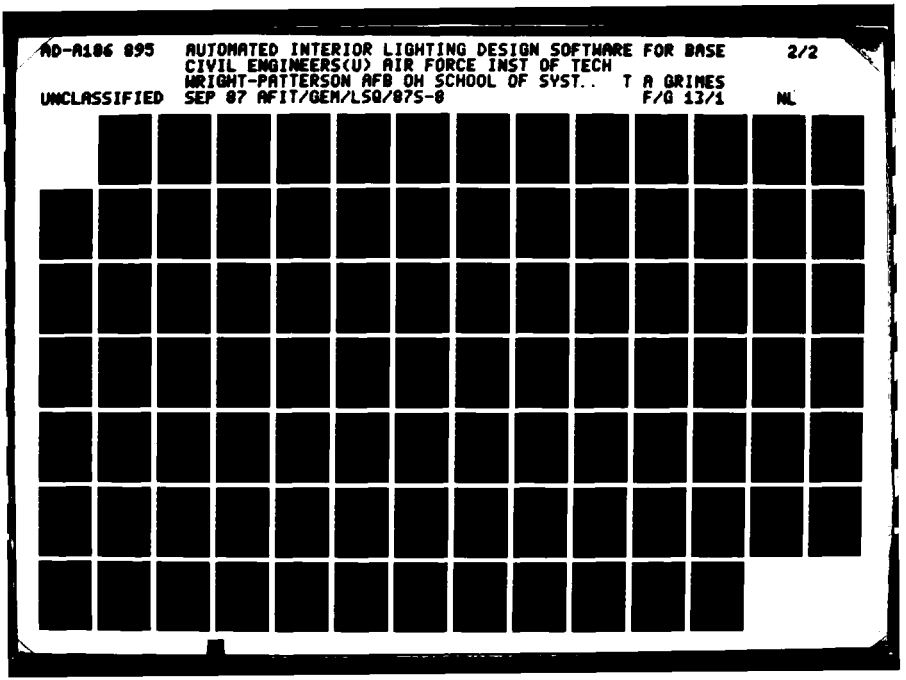
by hand verses 0.745 by computer). These differences are a factor of how LIGHT1A was programmed to use the effective reflectances table (Table 2.2.3). In developing the data set for reference by the program, this table was reduced to the equivalent of a 10 X 10 X 10 matrix. This was done to stay within the BASIC'S memory criteria. Any number needed that is not in the matrix directly is extrapolated. This extrapolation process causes the ceiling effective reflectance to be slightly off in this example, also resulting in the final CU value being lower. It should be noted that the effective floor reflectance was calculated the same way, using the same matrix, and that LIGHT1A's value matched exactly to what was calculated by hand. Also, although the final CU value of LIGHT1A was slightly lower, the final number of fixtures calculated remained the same after rounding (to obtain a whole number of fixtures occurred. Noting these slight differences, it can be concluded that LIGHT1A performs properly and within reasonable accuracy.

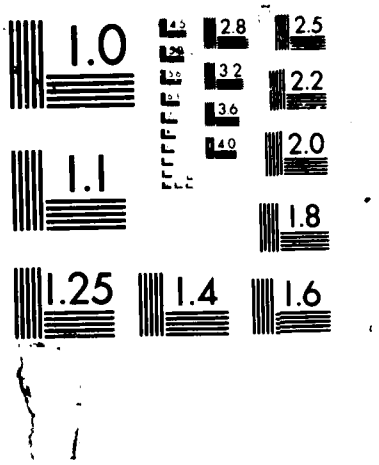
V. Conclusions and Recommendations

Conclusions

At the end of Chapter I, the stated objectives for this thesis effort were to develop a computer software package on interior lighting design that could be used by base civil engineering personnel; and in developing such a program, make it work on as many different computer brands as possible. Along with these objectives, it was stated that this software package should be distributed through the AFIT School of Civil Engineering and Services electrical engineering department, AFIT/DEE.

In addition to these basic objectives, Chapter III stated three basic considerations that were intended to be met during the actual programming stage of this thesis effort. The first consideration was to make the program "user friendly" by making it "menu driven." The actual program was set up so that the design engineer could choose to use the "menus" if desired. This option was given because once the design engineer becomes familiar with the program and its information requirements, he/she may not require the help that the menus are intended to give. The second programming consideration stated in Chapter III was the aspect of having a large set of information data files. These data files were required to support the use of "menus" in the program. During actual programming, the


AD-A186 895
AUTOMATED INTERIOR LIGHTING DESIGN SOFTWARE FOR BASE CIVIL ENGINEERS(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. T A GRIMES
2/2
UNCLASSIFIED
SEP 87 AFIT/GEM/LSQ/87S-8
F/G 13/1
NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

program was given both "changeable" and "unchangeable" data files. "Changeable" data files are required because the data contained within them requires periodic updating with "current" information. "Unchangeable" data files contain information pertinent to the lighting design method used (Zonal Cavity Method), and therefore do not need to be changed or updated. The third programming consideration pointed out in Chapter III was the fact that the program's results must be verified to ensure "usefulness." Chapter IV walks though an example problem which is used to demonstrate the accuracy of the program (reworking the same problem done in Chapter II by hand).

LIGHT1A is the software package that has been created in this thesis effort. The entire source code of LIGHT1A is contained in Appendix A. A diskette containing the source code may be obtained from AFIT/DEE, WPAFB, Ohio, 45433. This software package was created in a computer language called "BASIC" with the intent to make it as transportable as possible between computer brands. LIGHT1A has been tested on the Wang pc computer, as well as the Zenith Z-248 and the TeleVideo XL portable computer. By using the BASIC programming language, the lighting program itself should be easily expanded by the majority of engineers who have had any kind of programming experience. The electrical instructors at AFIT/DEE have reviewed

LIGHT1A, and will start distribution to the participants of the October, 1987 basic electrical design class.

Recommendations

Although LIGHT1A performs well, and does what it was intended to do, it does not cover all the aspects of lighting design. As stated throughout this thesis there are three major stages to lighting design. This program performs the first stage. The second stage of lighting design is the layout stage. In stage two, the number of fixtures calculated in the first stage are laid out in a pattern within the boundaries of the room. A graphics program that allows the design engineer to perform this activity on the computer would allow the design engineer to try many different layouts in a short period of time.

The third stage of lighting design is the "repeat" stage where the first two stages are repeated over and over allowing the design engineer to choose the best of a number of designs. LIGHT1A does not yet contain the ability to store the designs that are performed in computer memory for future reference. This ability would be very beneficial when considering the desirability of repeating designs. Thus it is recommended that LIGHT1A be expanded to allow the storage of performed calculations.

Appendix A: Line Code for Program LIGHT1A

This appendix contains the actual BASIC source code for the program entitled LIGHT1A that was developed for this thesis effort. The total program is made up of three sub-programs. These sub-program titles are listed below along with the page number that they each start on.

```
5 KEY OFF
10 CLS
14 PRINT TAB(15) " ---------------------------------------------- "
16 PRINT TAB(15) "|                                              |"
18 PRINT TAB(15) "|                                              |"
20 PRINT TAB(15) "|      Automated Interior Lighting Design      |"
22 PRINT TAB(15) "|                Version  1.01                 |"
24 PRINT TAB(15) "|                                              |"
26 PRINT TAB(15) "|                                              |"
28 PRINT TAB(15) "|    Copyright (c) 1987, Todd A. Grimes, P.E.  |"
30 PRINT TAB(15) "|                                              |"
32 PRINT TAB(15) "|                                              |"
34 PRINT TAB(15) "|    For information on this program contact:  |"
36 PRINT TAB(15) "|                                              |"
38 PRINT TAB(15) "|                   AFIT/DEE                   |"
40 PRINT TAB(15) "|  AFIT School of Civil Engineering & Services |"
42 PRINT TAB(15) "|                 WPAFB, OH  45433             |"
44 PRINT TAB(15) "|              Tel:  (513) 255-4552            |"
46 PRINT TAB(15) "|                                              |"
48 PRINT TAB(15) "|                                              |"
50 PRINT TAB(15) " ---------------------------------------------- "
52 PRINT :PRINT
54 PRINT TAB(26) :INPUT "Press <RETURN> to continue.", B$
100 REM ****************** MAIN PROGRAM MENU *********************************
105 REM
110 REM
115 CLS :PRINT :PRINT
120 PRINT TAB(36) "MENU -- A"
125 PRINT :PRINT
130 PRINT TAB(20) "TYPE"; TAB(40) "PROCEDURE"
135 PRINT :PRINT
140 PRINT TAB(21) "1"; TAB(40) "Calculation Program"
145 PRINT
150 PRINT TAB(21) "2"; TAB(40) "Update/Hardcopy Program"
155 PRINT :PRINT
160 PRINT TAB(21) "3"; TAB(40) "END"
165 PRINT :PRINT :PRINT :PRINT TAB(20);
170 INPUT "Please enter selected procedure: ", B
175 ON B GOTO 205,230,195
180 GOTO 115
185 REM
190 REM
195 CLS
200 SYSTEM
205 CLS :PRINT :PRINT :PRINT :PRINT :PRINT
206 PRINT TAB(31) "PLEASE BE PATIENT"
207 PRINT
210 PRINT TAB(32) "LOADING PROGRAM"
215 CHAIN "A:PROGRAM1"
220 GOTO 115
225 REM
230 CLS :PRINT :PRINT :PRINT :PRINT :PRINT
231 PRINT TAB(31) "PLEASE BE PATIENT"
232 PRINT
235 PRINT TAB(32) "LOADING PROGRAM"
240 CHAIN "A:PROGRAM2"
245 GOTO 115
250 REM
255 REM
```

```
100 CLS
105 PRINT :PRINT :PRINT :PRINT :PRINT :PRINT
110 PRINT TAB(18) "Please place your DATA DISK in the 'A' drive."
115 PRINT :PRINT :PRINT
120 INPUT "                              Press <RETURN> when ready. ", B$
125 REM
130 CLEAR
135 DEFINT A-E
200 REM
202 DIM RSDF(5,2) :DIM LA(6,5)
206 DIM ACU(4) :DIM BCU(4)
210 DIM RMUSE$(36) :DIM RMUSELEVEL(36) :DIM RMDTCD$(5,5)
214 DIM MFACT(2,5)
218 DIM MFACTOR(3,20)
222 DIM EFF(10,10)
226 DIM PTMAN$(30) :DIM PTCOLOR$(30) :DIM PTREFL(30)
230 DIM SOURCE$(5,2)
236 DIM PFR(4) :DIM PCR(5) :DIM PWR(4)
240 DIM DTYPE$(5,3)
244 DIM MCAT$(6,7)
248 DIM LCODE$(5,10,2) :DIM LAMPDATA(5,10,3)
252 DIM FCODE$(5,10,4)  :DIM FIXTDATA (5,10,2)
256 DIM CU1(10,4,2) :DIM CU2(10,3,2)
260 DIM CU3(10,4,1) :DIM CU4(10,3,2)
500 REM
502 SOURCE$(1,1)="Incandescent"          :SOURCE$(1,2)="INC"
504 SOURCE$(2,1)="Fluorescent"           :SOURCE$(2,2)="F"
506 SOURCE$(3,1)="Mercury Vapor"         :SOURCE$(3,2)="MV"
508 SOURCE$(4,1)="Metal Halide"          :SOURCE$(4,2)="MH"
510 SOURCE$(5,1)="High Pressure Sodium"  :SOURCE$(5,2)="HPS"
512 REM
514 DTYPE$(1,1)="Indirect"          :DTYPE$(1,2)="90-100"  :DTYPE$(1,3)="0-10"
516 DTYPE$(2,1)="Semi-Indirect"     :DTYPE$(2,2)="60-90"   :DTYPE$(2,3)="10-40"
518 DTYPE$(3,1)="Direct-Indirect"   :DTYPE$(3,2)="40-60"   :DTYPE$(3,3)="60-40"
520 DTYPE$(4,1)="Semi-Direct"       :DTYPE$(4,2)="10-40"   :DTYPE$(4,3)="60-90"
522 DTYPE$(5,1)="Direct"            :DTYPE$(5,2)="0-10"    :DTYPE$(5,3)="90-100"
524 REM
526 PFR(1)=30  :PFR(2)=20  :PFR(3)=10  :PFR(4)=0
528 PCR(1)=80  :PCR(2)=70  :PCR(3)=50  :PCR(4)=30  :PCR(5)=10
530 PWR(1)=70  :PWR(2)=50  :PWR(3)=30  :PWR(4)=10
532 REM
534 LA(1,1)=.038 :LA(1,2)=.071 :LA(1,3)=.111 :LA(1,4)=.162 :LA(1,5)=.201
536 LA(2,1)=.033 :LA(2,2)=6.800001E-02 :LA(2,3)=.102 :LA(2,4)=.147 :LA(2,5)=.188
538 LA(3,1)=7.900001E-02 :LA(3,2)=.106 :LA(3,3)=.143 :LA(3,4)=.184 :LA(3,5)=.236
540 LA(4,1)=.07 :LA(4,2)=.131 :LA(4,3)=.216 :LA(4,4)=.314 :LA(4,5)=.452
542 LA(5,1)=.079 :LA(5,2)=.128 :LA(5,3)=.19 :LA(5,4)=.249 :LA(5,5)=.321
544 LA(6,1)=.076 :LA(6,2)=.145 :LA(6,3)=.218 :LA(6,4)=.284 :LA(6,5)=.396
546 REM
548 MFACT(1,1)=1.051 :MFACT(1,2)=1.044 :MFACT(1,3)=1.029 :MFACT(1,4)=1.017
550 MFACT(1,5)=1.009 :MFACT(2,1)=.918  :MFACT(2,2)=.926  :MFACT(2,3)=.953
552 MFACT(2,4)=.97   :MFACT(2,5)=.986
554 REM
556 RSDF(5,1)=.92 :RSDF(4,1)=.84 :RSDF(3,1)=.76 :RSDF(2,1)=.73 :RSDF(1,1)=.6
558 RSDF(5,2)=.83 :RSDF(4,2)=.72 :RSDF(3,2)=.67 :RSDF(2,2)=.67 :RSDF(1,2)=.5
560 REM
562 ITERATE = 1
564 REM
1000 REM
1005 OPEN "I", #1, "A:AFF8815.INF"
1010 FOR A=1 TO 36
1015 INPUT#1, RMUSE$(A), RMUSELEVEL(A)
```

```
1020 NEXT A
1025 CLOSE #1
1030 REM
1035 REM
1040 OPEN "I", #1, "A:RMDIRT.INF"
1045 FOR A=1 TO 5
1050 FOR B=1 TO 6
1055 INPUT#1, RMDTCD$(A,B)
1060 NEXT B
1065 NEXT A
1070 CLOSE #1
1075 REM
1080 REM
1085 OPEN "I", #1, "A:MAINTCAT.INF"
1090 FOR A=1 TO 6
1095 FOR B=1 TO 7
1100 INPUT#1, MCAT$(A,B)
1105 NEXT B
1110 NEXT A
1115 CLOSE #1
1120 REM
1125 REM
1130 OPEN "I", #1, "A:REFLECTR.DAT"
1135 FOR A=1 TO 30
1140 INPUT #1, PTMAN$(A), PTCOLOR$(A), PTREFL(A)
1145 NEXT A
1150 CLOSE #1
1155 REM
1160 REM
1165 OPEN "I", #1, "A:LAMPDATA.DAT"
1170 FOR A=1 TO 5
1175 FOR B=1 TO 10
1180 INPUT#1, LCODE$(A,B,1), LCODE$(A,B,2)
1185 INPUT#1, LAMPDATA(A,B,1), LAMPDATA(A,B,2), LAMPDATA(A,B,3)
1190 NEXT B
1195 NEXT A
1200 CLOSE #1
1205 REM
1210 REM
1215 OPEN "I", #1, "A:FIXTDATA.DAT"
1220 FOR A=1 TO 5
1225 FOR B=1 TO 10
1230 INPUT#1, FCODE$(A,B,1), FCODE$(A,B,2), FCODE$(A,B,3), FCODE$(A,B,4)
1235 INPUT#1, FIXTDATA(A,B,1), FIXTDATA(A,B,2)
1240 NEXT B
1245 NEXT A
1250 CLOSE #1
1255 REM
1260 REM
5100 REM ****************** MENU -- B ****************************************
5105 REM
5110 REM
5115 CLS
5120 PRINT ,,"MENU -- B"
5125 PRINT :PRINT
5130 PRINT ,"TYPE ",,"PROCEDURE"
5135 PRINT :PRINT :PRINT
5140 PRINT ,"1","New Room Calcs  -  Fixture Number, w/o Tables"
5145 PRINT :PRINT
5150 PRINT ,"2","New Room Calcs  -  Fixture Number, with Tables"
5155 PRINT :PRINT
5160 PRINT ,"3","RETURN TO MAIN MENU"
5165 PRINT :PRINT :PRINT :PRINT TAB(10);
5170 INPUT "Please enter selected procedure:     ", B
5175 REM
```

```
5180 ON B GOTO 10100,11100,5190
5185 GOTO 5115
5190 CLS :PRINT :PRINT :PRINT :PRINT
5195 PRINT TAB(20) "Place your PROGRAM DISK in the 'A' drive."
5200 PRINT :PRINT
5205 PRINT TAB(26);: :INPUT "Press  RETURN  when ready.", B$
5210 PRINT :PRINT :PRINT
5215 PRINT TAB(31) "LOADING MENU -- A"
5220 CHAIN "A:LIGHT1A",100
5225 REM
5230 REM
10100 REM ****************** NEW ROOM W/O TABLES *******************************
10105 REM
10110 REM
10115 GOSUB 12100
10120 IF B=2 THEN 5100
10125 GOSUB 40100
10130 REM
10135 GOSUB 50115
10140 REM
10145 GOSUB 42100
10150 REM
10155 GOSUB 50190
10160 REM
10165 GOSUB 44150
10170 REM
10175 GOSUB 20100
10180 ON B GOSUB 40100,50115,42100,50190,44150
10185 IF B=0 THEN GOTO 10200
10190 GOTO 10175
10195 REM
10200 GOSUB 24100
10205 REM
10210 GOSUB 45100
10215 IF STTAB=1 THEN GOSUB 51100
10220 REM
10225 GOSUB 21100
10230 ON B GOSUB 47100,48100
10240 IF B=0 GOTO 10255
10241 IF B=3 THEN 10210
10245 GOTO 10230
10250 REM
10255 GOSUB 25100
10260 REM
10265 IF DISTTYP = 1 OR DISTTYP = 6 THEN 10275
10270 GOTO 10290
10275 PRINT
10280 INPUT "You must identify a fixture type, press  RETURN  to continue. ", B$
10285 GOTO 10210
10290 GOSUB 26100
10295 REM
10300 GOSUB 29100
10305 REM
10310 GOSUB 22100
10315 REM
10320 GOSUB 30100
10325 REM
10330 GOSUB 23100
10335 REM
10340 ON B GOTO 10125,130,57100
10345 GOTO 10350
10350 REM
10355 REM
11100 REM ****************** NEW ROOM W. TABLES ********************************
11105 REM
```

```
11110 REM
11115 GOSUB 13100
11120 IF B=2 THEN 5100
11125 REM
11130 GOSUB 20100
11135 ON B GOSUB 40100,41100,42100,43100,44100
11140 IF B=0 GOTO 11155
11145 GOTO 11130
11150 REM
11155 GOSUB 24100
11160 REM
11165 GOSUB 45100
11170 REM
11175 IF STTAB=2 THEN GOSUB 51100 ELSE 11190
11185 REM
11190 GOSUB 21100
11195 ON B GOSUB 47100, 48100
11200 IF B=0 GOTO 11215
11201 IF B=3 THEN 11165
11205 GOTO 11190
11210 REM
11215 GOSUB 25100
11220 REM
11225 IF DISTYP  1 OR DISTYP  3 THEN 11235
11230 GOTO 11250
11235 PRINT
11240 INPUT "You must identify a fixture type, press <RETURN> to continue. ", B$
11245 GOTO 11165
11250 GOSUB 26100
11255 REM
11260 GOSUB 29100
11265 REM
11270 GOSUB 22100
11275 REM
11280 GOSUB 30100
11285 REM
11290 GOSUB 23100
11295 REM
11300 ON B GOTO 11130,130,57100
11305 REM
11310 REM
12100 REM ****************** W/O TABLE INTRO ***********************************
12105 REM
12110 REM
12115 CLS :PRINT :PRINT :PRINT :PRINT
12120 PRINT TAB(27) "INSTRUCTIONS -- W/O TABLES"
12125 PRINT :PRINT :PRINT
12130 PRINT TAB(13) "This procedure will prompt you with questions that"
12135 PRINT TAB(13) "you need to answer so that the calculations can be"
12140 PRINT TAB(13) "performed.  If you cannot answer these questions,"
12145 PRINT TAB(13) "you should return to MENU -- 8, and use the other"
12150 PRINT TAB(13) "procedure available -- 'Fixture Number, with Tables. "
12155 PRINT :PRINT
12160 PRINT TAB(13) "Enter (1) to continue,"
12165 PRINT TAB(13) "      (2) to return to MENU -- 8"
12170 PRINT TAB(13) :INPUT "      "; B
12175 RETURN
12180 REM
12185 REM
13100 REM ****************** WITH TABLE INTRO **********************************
13105 REM
13110 REM
13115 CLS :PRINT :PRINT :PRINT :PRINT
13120 PRINT TAB 27) "INSTRUCTIONS -- WITH TABLES"
13125 PRINT :PRINT :PRINT
```

```
13130 PRINT TAB(13) "This procedure will give you screens that must be "
13135 PRINT TAB(13) "filled out.  One screen will be for the room "
13140 PRINT TAB(13) "information, the other screen will be for the fixture"
13145 PRINT TAB(13) "information.  To fill out the screens, simply enter"
13150 PRINT TAB(13) "the number to the right of the major topic desired."
13155 PRINT TAB(13) "Tables will be given to you when possible allowing"
13160 PRINT TAB(13) "you to choose the best answer for your situation."
13165 PRINT :PRINT
13170 PRINT TAB(13) "Enter (1) to continue."
13175 PRINT TAB(13) "      (2) to return to MENU -- B"
13180 PRINT TAB(13) :INPUT "     "; B
13185 RETURN
13190 REM
13195 REM
20100 REM ****************** SCREEN 1 ****************************************
20105 REM
20110 REM
20115 CLS
20120 PRINT "                          ";
20125 PRINT "ROOM INFORMATION REQUIREMENTS"
20130 PRINT
20135 PRINT "  (1) REFERENCE DATA:"
20140 PRINT
20145 PRINT "      Building # "; BLDG$;
20150 PRINT TAB(28) "Room # "; ROOM$;
20155 PRINT TAB(55) "Iteration:"; ITERATE
20160 PRINT
20165 PRINT "  (2) Room Use: "; ROOMUSE$;
20170 PRINT TAB(43) "FC Requirements:"; FCLEVEL
20175 PRINT
20180 PRINT "  (3) ROOM DIMENSIONS:"
20185 PRINT TAB(55) "Ceiling Height:"; FTCHGT
20190 PRINT "      Length:"; RMLGTH;
20195 PRINT TAB(28) "Perimeter:"; RMPER;
20200 PRINT TAB(55) "Fixture Height:"; FTFHGT
20205 PRINT "      Width: "; RMWDTH;
20210 PRINT TAB(28) "Area:     "; RMFAREA;
20215 PRINT TAB(55) "Working Height:"; FTWSHGT
20220 PRINT
20225 PRINT "  (4) ROOM REFLECTANCES:"
20230 PRINT
20235 REM
20240 PRINT "      Ceiling Color: "; CLCOLOR$;
20245 PRINT TAB(43) "Reflectance:"; CEILREF;
20250 PRINT "%"
20255 PRINT "      Wall Color:    "; WLCOLOR$;
20260 PRINT TAB(43) "Reflectance:" WALLREF;
20265 PRINT "%"
20270 PRINT "      Floor Color:   "; FLCOLOR$;
20275 PRINT TAB(43) "Reflectance:"; FLOOREF;
20280 PRINT "%"
20285 PRINT
20290 PRINT "  (5) Room Condition: "; DIRTCD$;
20295 PRINT TAB(43) "Cleaning Cycle: "; CLCYCLE;" months"
20300 PRINT :PRINT
20305 INPUT "Enter selection # (x) for data input, or (0) to continue: ", B
20310 REM
20315 RETURN
20320 REM
20325 REM
21100 REM ****************** SCREEN 2 ****************************************
21105 REM
21110 REM
21115 CLS
21120 REM
```

```
21125 PRINT TAB(23) "LUMINAIRE INFORMATION REQUIREMENTS"
21130 PRINT :PRINT
21135 PRINT "      Building # "; BLDG$;
21140 PRINT TAB(33) "Room # "; ROOM$;
21145 PRINT TAB(55) "Iteration: "; ITERATE
21150 PRINT :PRINT
21155 PRINT "  (1) LUMINAIRE INFORMATION:"
21160 PRINT
21165 PRINT "      Fixture File # "; FIXTFILE$;
21170 PRINT TAB(40) "S/MH Ratio:          "; STMHRAT
21175 PRINT "      Fixture Make:  "; FIXTMAKE$;
21180 PRINT TAB(40) "Maintenance Catagory:  "; MAINCAT$
21185 PRINT "      Fixture Model: "; FIXTMODEL$;
21190 PRINT TAB(40) "Distribution Type:    "; DISTTYP
21195 PRINT
21200 PRINT "  (2) LAMP INFORMATION: "
21205 PRINT
21210 PRINT "      Lamp File # "; LAMPFILE$;
21215 PRINT TAB(40) "Lamp Watts:        "; LWATTS
21220 PRINT "      Lamp Type:  "; LTYPE$;
21225 PRINT TAB(40) "Initial Lumens:    "; INITLUM
21230 PRINT "      Quantity:  "; LQUANT;
21235 PRINT TAB(40) "Maintained Lumens: "; MAINTLUM
21240 PRINT
21241 PRINT "  (3) DIFFERENT SOURCE TYPE"
21245 PRINT :PRINT
21250 INPUT "Enter selection # (x) for data input, or (0) to continue: ", B
21255 REM
21260 RETURN
21265 REM
21270 REM
22100 REM ****************** SCREEN 3 ****************************************
22105 REM
22110 REM
22115 CLS
22120 PRINT TAB(28) "FINAL DESIGN CALCULATIONS"
22125 PRINT
22130 PRINT "     Building # "; BLDG$;
22135 PRINT TAB(30) "Room # "; ROOM$;
22140 PRINT TAB(60) "Iteration: "; ITERATE
22145 PRINT
22150 PRINT "     Room Use: "; ROOMUSE$;
22155 PRINT TAB(60) "FC Required: "; FCLEVEL
22160 PRINT
22165 PRINT "          CCR = "; USING "##.##"; CCAVRAT;
22170 PRINT TAB(30) "Ceiling Reflectance: "; CEILREF;
22175 PRINT TAB(60) "Effective:   "; EFFCREF
22180 PRINT "          RCR = "; USING "##.##"; RCAVRAT;
22185 PRINT TAB(30) "Wall Reflectance:    "; WALLREF
22190 PRINT "          FCR = "; USING "##.##"; FCAVRAT;
22195 PRINT TAB(30) "Floor Reflectance:   "; FLOOREF;
22200 PRINT TAB(60) "Effective:   "; EFFFREF
22205 PRINT
22210 PRINT "     Fixture Make: "; FIXTMAKE$;
22215 PRINT TAB(36) "Model # "; FIXTMODEL$;
22220 PRINT TAB(59) LQUANT; " tube"
22225 PRINT
22230 PRINT "          Critical";
22235 PRINT TAB(20) "PFR"; " :"; TAB(25) PFR(2);
22240 PRINT TAB(60) "S/MH Ratio ="; STMHRAT
22245 PRINT "          CU";
22250 PRINT TAB(20) "PCR"; " :"; TAB(25) PCR(D1);
22255 IF D2 > 0 THEN PRINT TAB(36) PCR(D2);
22260 PRINT ""
22265 PRINT "          Values "; TAB(20) "FWR"; " :"; TAB(25) FWR(C1);
```

```
22270 IF C2 > 0 THEN PRINT TAB(30) PWR(C2);
22275 IF D2 > 0 THEN PRINT TAB(36) PWR(D2); ELSE 22285
22280 IF C2 > 0 THEN PRINT TAB(41) PWR(C2);
22285 PRINT TAB(60) "Total LLF  = "; USING "#.###"; LLF
22290 PRINT TAB(20) "RCR"; " |"
22295 PRINT TAB(20) "----|-------------------";
22300 PRINT TAB(60) "Final  CU  = "; USING "#.###"; FINALCU
22305 PRINT TAB(19) ARATIO; TAB(24) "|"; TAB(25) ACU(1);
22310 IF C2 > 0 THEN PRINT TAB(30) ACU(2);
22315 IF D2 > 0 THEN PRINT TAB(36) ACU(3); ELSE 22325
22320 IF C2 > 0 THEN PRINT TAB(41) ACU(4);
22325 PRINT ""
22330 IF E1=1 THEN 22360
22335 PRINT TAB(19) BRATIO; TAB(24) "|"; TAB(25) BCU(1);
22340 IF C2 > 0 THEN PRINT TAB(30) BCU(2);
22345 IF D2 > 0 THEN PRINT TAB(36) BCU(3); ELSE 22355
22350 IF C2 > 0 THEN PRINT TAB(41) BCU(4);
22355 PRINT ""
22360 PRINT :PRINT
22365 PRINT "     Number of Fixtures Required: "; USING "###.##"; NUMFIX
22370 PRINT
22375 INPUT "     How many fixtures do you want to use "; ACTFIXNUM
22380 REM
22385 RETURN
22390 REM
22395 REM
23100 REM ****************** SCREEN 4 ****************************************
23105 REM
23110 REM
23115 CLS
23120 PRINT TAB(28) "FINAL DESIGN CALCULATIONS"
23125 PRINT
23130 PRINT "     Building # "; BLDG$;
23135 PRINT TAB(30) "Room # "; ROOM$;
23140 PRINT TAB(60) "Iteration: "; ITERATE
23145 PRINT
23150 PRINT "     Room Use: "; ROOMUSE$;
23155 PRINT TAB(60) "FC Required: "; FCLEVEL
23160 PRINT
23165 PRINT "     Fixture Make: "; FIXTMAKE$;
23170 PRINT TAB(36) "Model # "; FIXTMODEL$;
23175 PRINT TAB(59) LQUANT: " tube"
23180 PRINT :PRINT
23185 PRINT "          LLD =       "; USING "#.###"; LLD;
23190 PRINT TAB(45) "Floor Cavity Factor =    "; USING "#.###"; KOEF
23195 PRINT "          LDD =       "; USING "#.###"; LDD;
23200 PRINT TAB(45) "Final CU Value =         "; USING "#.###"; FINALCU
23205 PRINT "          RSDD =      "; USING "#.###"; RSDD
23210 PRINT "          Total LLF = "; USING "#.###"; LLF;
23215 PRINT TAB(45) "S/MH Ratio =             "; STMHRAT
23220 PRINT TAB(45) "Spacing Criteria (ft): "; USING "###.#"; SPCCRIT
23225 PRINT
23230 PRINT "     Initial FC Level:    "; ACTFCINIT;
23235 PRINT TAB(45) "Fixture # Required:    "; USING "###.##"; NUMFIX
23240 PRINT "     Maintained FC Level: "; ACTFCMAIN;
23245 PRINT TAB(45) "Fixture # Used:        "; ACTFIXNUM
23250 PRINT :PRINT
23255 PRINT "     ENTER:"
23260 PRINT "       (1)    To do another iteration of this room"
23265 PRINT "       (2)    To go to Menu -- B, clearing all variables"
23270 PRINT "       (3)    To get a hardcopy, and return to this screen"
23275 PRINT "     ";
23280 INPUT B
23285 REM
23290 IF B=1 THEN ITERATE = ITERATE + 1
```

```
23295 REM
23300 RETURN
23305 REM
23310 REM
24100 REM ************** EFFECTIVE REFLECTANCE **********************************
24105 REM
24110 REM
24115 D=1
24120 REM
24125 BWALL = WALLREF
24130 IF D=1 THEN BBASE = CEILREF
24135 IF D=1 THEN RRAT = TCAVRAT
24140 REM
24145 IF D=2 THEN BBASE = FLOOREF
24150 IF D=2 THEN RRAT = FCAVRAT
24155 REM
24160 IF RRAT=0 THEN 24520
24165 REM
24170 IF BBASE   85 THEN OPEN "I", #1, "A:EFFREF9.EFF" ELSE 24180
24175 GOTO 24270
24180 IF BBASE / 75 THEN OPEN "I", #1, "A:EFFREF8.EFF" ELSE 24190
24185 GOTO 24270
24190 IF BBASE : 65 THEN OPEN "I", #1, "A:EFFREF7.EFF" ELSE 24200
24195 GOTO 24270
24200 IF BBASE / 55 THEN OPEN "I", #1, "A:EFFREF6.EFF" ELSE 24210
24205 GOTO 24270
24210 IF BBASE : 45 THEN OPEN "I", #1, "A:EFFREF5.EFF" ELSE 24220
24215 GOTO 24270
24220 IF BBASE / 35 THEN OPEN "I", #1, "A:EFFREF4.EFF" ELSE 24230
24225 GOTO 24270
24230 IF BBASE   25 THEN OPEN "I", #1, "A:EFFREF3.EFF" ELSE 24240
24235 GOTO 24270
24240 IF BBASE   15 THEN OPEN "I", #1, "A:EFFREF2.EFF" ELSE 24250
24245 GOTO 24270
24250 IF BBASE   5 THEN OPEN "I", #1, "A:EFFREF1.EFF" ELSE 24260
24255 GOTO 24270
24260 OPEN "I", #1, "A:EFFREF0.EFF"
24265 REM
24270 FOR A=1 TO 10
24275 FOR B=1 TO 10
24280 INPUT #1, EFF(A,B)
24285 NEXT B
24290 NEXT A
24295 CLOSE #1
24300 REM
24305 C=0
24310 IF BBASE : 5 THEN C=10
24315 IF BBASE / 15 THEN C=20
24320 IF BBASE : 25 THEN C=30
24325 IF BBASE : 35 THEN C=40
24330 IF BBASE : 45 THEN C=50
24335 IF BBASE : 55 THEN C=60
24340 IF BBASE : 65 THEN C=70
24345 IF BBASE : 75 THEN C=80
24350 IF BBASE   85 THEN C=90
24355 REM
24360 A=10
24365 IF BWALL : 5 THEN A=9
24370 IF BWALL   15 THEN A=8
24375 IF BWALL   25 THEN A=7
24380 IF BWALL   35 THEN A=6
24385 IF BWALL   45 THEN A=5
24390 IF BWALL   55 THEN A=4
24395 IF BWALL   65 THEN A=3
24400 IF BWALL   75 THEN A=2
```

```
24405 IF BWALL > 85 THEN A=1
24410 REM
24415 REM
24420 ARAT = RRAT
24425 IF ARAT > RRAT THEN BRAT=ARAT-1 ELSE BRAT=ARAT+1
24430 IF ARAT > BRAT THEN CRAT=ARAT ELSE 24440
24435 ARAT = BRAT  :BRAT = CRAT
24440 IF ARAT=0 THEN EFFRAT1=0 ELSE 24455
24445 GOTO 24460
24450 REM
24455 EFFRAT1 = EFF(A,ARAT)
24460 EFFRAT2 = EFF(A,BRAT)
24465 REM
24470 EFFRAT3 = EFFRAT1-((EFFRAT1-EFFRAT2)*(RRAT-ARAT))
24475 REM
24480 REM
24485 IF D=1 THEN EFFCREF = EFFRAT3
24490 IF D=2 THEN EFFFREF = EFFRAT3
24495 IF D=1 THEN D=2 ELSE 24510
24500 GOTO 24125
24505 REM
24510 RETURN
24515 REM
24520 IF D=1 THEN EFFCREF = CEILREF
24525 IF D=2 THEN EFFFREF = FLOOREF
24530 IF D=1 THEN D=2 ELSE 24545
24535 GOTO 24125
24540 REM
24545 RETURN
24550 REM
24555 REM
25100 REM ****************** (LDD) LUMINAIRE DIRT DEP. ************************
25105 REM
25110 REM
25115 IF MAINCAT$="I" THEN LLB = .69
25120 IF MAINCAT$="II" THEN LLB = .62
25125 IF MAINCAT$="III" THEN LLB = .7
25130 IF MAINCAT$="IV" THEN LLB = .72
25135 IF MAINCAT$="V" THEN LLB = .53
25140 IF MAINCAT$="VI" THEN LLB = .88
25145 REM
25150 IF MAINCAT$="I" THEN AA1 = 1
25155 IF MAINCAT$="II" THEN AA1 = 2
25160 IF MAINCAT$="III" THEN AA1 = 3
25165 IF MAINCAT$="IV" THEN AA1 = 4
25170 IF MAINCAT$="V" THEN AA1 = 5
25175 IF MAINCAT$="VI" THEN AA1 = 6
25180 REM
25185 IF DIRTCD$="Very Clean" THEN AA2 = 1
25190 IF DIRTCD$="Clean" THEN AA2 = 2
25195 IF DIRTCD$="Medium" THEN AA2 = 3
25200 IF DIRTCD$="Dirty" THEN AA2 = 4
25205 IF DIRTCD$="Very Dirty" THEN AA2 = 5
25210 REM
25215 LLA = LA(AA1,AA2)
25220 REM
25225 T = CLCYCLE / 12
25230 REM
25235 LDD = EXP(-LLA*(T^LLB))
25240 REM
25245 REM
25250 REM ****************** (RSDD) ROOM SURFACE DIRT DEP.
25255 REM
25260 REM
25265 IF DIRTCD$="Very Clean" THEN RSD = 1-(EXP(-.079*(T .53)))+10
```

```
25270 IF DIRTCD$="Clean"      THEN PDD = (1-(EXP(-.129*(T .53))))*10
25275 IF DIRTCD$="Medium"     THEN PDD = (1-(EXP(-.19*(T .53))))*10
25280 IF DIRTCD$="Dirty"      THEN PDD = (1-(EXP(-.249*(T .53))))*10
25285 IF DIRTCD$="Very Dirty" THEN PDD = (1-(EXP(-.321*(T .53))))*10
25290 REM
25295 IF RCAVRAT < 1 THEN RSDD = 1 ELSE 25310
25300 GOTO 25365
25305 REM
25310 IF PDD > 4 THEN 25320
25315 GOTO 25340
25320 RSD1 = RSDF(DISTTYP,1)
25325 RSD2 = RSDF(DISTTYP,2)
25330 GOTO 25355
25335 REM
25340 RSD1 = 1-(((1-RSDF(DISTTYP,1))/4)*PDD)
25345 RSD2 = 1-(((1-RSDF(DISTTYP,2))/4)*PDD)
25350 REM
25355 RSDD = RSD1-(((RSD1-RSD2)/9)*(RCAVRAT-1))
25360 REM
25365 REM
25370 REM ****************** (LLD) LAMP LUMEN DEP.
25375 REM
25380 REM
25385 IF MAINTLUM = 0 THEN LLD = .85 ELSE 25400
25390 GOTO 25405
25395 REM
25400 LLD = MAINTLUM / INITLUM
25405 REM
25410 REM
25415 REM ****************** (LLF) LIGHT LOSS FACTOR
25420 REM
25425 REM
25430 LLF = LLD * RSDD * LDD
25435 REM
25440 RETURN
25445 REM
25450 REM
26100 REM ****************** CHARTED CU VALUES *********************************
26105 REM
26110 REM
26115 E1 = 0
26120 ACREF = EFFCREF
26125 AWREF = WALLREF
26130 AFREF = EFFFREF
26135 REM
26140 ARATIO = RCAVRAT
26145 IF ARATIO > RCAVRAT THEN BRATIO = ARATIO-1 ELSE BRATIO = ARATIO+1
26150 IF ARATIO < BRATIO THEN CRATIO = ARATIO ELSE 26165
26155 ARATIO = BRATIO  :BRATIO = CRATIO
26160 IF ARATIO = 0 THEN E1 = 1
26165 IF ARATIO = 0 THEN ARATIO = 1
26170 IF BRATIO = 11 THEN E1 = 1
26175 IF BRATIO = 11 THEN BRATIO = 10
26180 REM
26185 REM
26190 IF STTAB = 2 THEN 27845
26195 CLS
26200 PRINT :PRINT :PRINT :PRINT :PRINT
26205 PRINT TAB(34) "READING DATA"
26210 REM
26215 IF SOL=1 THEN 26245
26220 IF SOL=2 THEN 26300
26225 IF SOL=3 THEN 26440
26230 IF SOL=4 THEN 26495
26235 IF SOL=5 THEN 26550
```

```
26240 REM
26245 IF FFC=1 THEN OPEN "I", #1, "A:INCU1.DAT"
26250 IF FFC=2 THEN OPEN "I", #1, "A:INCU2.DAT"
26255 IF FFC=3 THEN OPEN "I", #1, "A:INCU3.DAT"
26260 IF FFC=4 THEN OPEN "I", #1, "A:INCU4.DAT"
26265 IF FFC=5 THEN OPEN "I", #1, "A:INCU5.DAT"
26270 IF FFC=6 THEN OPEN "I", #1, "A:INCU6.DAT"
26275 IF FFC=7 THEN OPEN "I", #1, "A:INCU7.DAT"
26280 IF FFC=8 THEN OPEN "I", #1, "A:INCU8.DAT"
26285 IF FFC=9 THEN OPEN "I", #1, "A:INCU9.DAT"
26290 IF FFC=10 THEN OPEN "I", #1, "A:INCU10.DAT"
26295 GOTO 26355
26300 IF FFC=1 THEN OPEN "I", #1, "A:FLCU1.DAT"
26305 IF FFC=2 THEN OPEN "I", #1, "A:FLCU2.DAT"
26310 IF FFC=3 THEN OPEN "I", #1, "A:FLCU3.DAT"
26315 IF FFC=4 THEN OPEN "I", #1, "A:FLCU4.DAT"
26320 IF FFC=5 THEN OPEN "I", #1, "A:FLCU5.DAT"
26325 IF FFC=6 THEN OPEN "I", #1, "A:FLCU6.DAT"
26330 IF FFC=7 THEN OPEN "I", #1, "A:FLCU7.DAT"
26335 IF FFC=8 THEN OPEN "I", #1, "A:FLCU8.DAT"
26340 IF FFC=9 THEN OPEN "I", #1, "A:FLCU9.DAT"
26345 IF FFC=10 THEN OPEN "I", #1, "A:FLCU10.DAT"
26350 REM
26355 FOR D=1 TO 2
26360 FOR C=1 TO 4
26365 FOR B=1 TO 10
26370 INPUT#1, CU1(B,C,D)
26375 NEXT B
26380 NEXT C
26385 NEXT D
26390 FOR D=1 TO 2
26395 FOR C=1 TO 3
26400 FOR B=1 TO 10
26405 INPUT#1, CU2(B,C,D)
26410 NEXT B
26415 NEXT C
26420 NEXT D
26425 CLOSE #1
26430 GOTO 26690
26435 REM
26440 IF FFC=1 THEN OPEN "I", #1, "A:MVCU1.DAT"
26445 IF FFC=2 THEN OPEN "I", #1, "A:MVCU2.DAT"
26450 IF FFC=3 THEN OPEN "I", #1, "A:MVCU3.DAT"
26455 IF FFC=4 THEN OPEN "I", #1, "A:MVCU4.DAT"
26460 IF FFC=5 THEN OPEN "I", #1, "A:MVCU5.DAT"
26465 IF FFC=6 THEN OPEN "I", #1, "A:MVCU6.DAT"
26470 IF FFC=7 THEN OPEN "I", #1, "A:MVCU7.DAT"
26475 IF FFC=8 THEN OPEN "I", #1, "A:MVCU8.DAT"
26480 IF FFC=9 THEN OPEN "I", #1, "A:MVCU9.DAT"
26485 IF FFC=10 THEN OPEN "I", #1, "A:MVCU10.DAT"
26490 GOTO 26605
26495 IF FFC=1 THEN OPEN "I", #1, "A:MHCU1.DAT"
26500 IF FFC=2 THEN OPEN "I", #1, "A:MHCU2.DAT"
26505 IF FFC=3 THEN OPEN "I", #1, "A:MHCU3.DAT"
26510 IF FFC=4 THEN OPEN "I", #1, "A:MHCU4.DAT"
26515 IF FFC=5 THEN OPEN "I", #1, "A:MHCU5.DAT"
26520 IF FFC=6 THEN OPEN "I", #1, "A:MHCU6.DAT"
26525 IF FFC=7 THEN OPEN "I", #1, "A:MHCU7.DAT"
26530 IF FFC=8 THEN OPEN "I", #1, "A:MHCU8.DAT"
26535 IF FFC=9 THEN OPEN "I", #1, "A:MHCU9.DAT"
26540 IF FFC=10 THEN OPEN "I", #1, "A:MHCU10.DAT"
26545 GOTO 26605
26550 IF FFC=1 THEN OPEN "I", #1, "A:HPCU1.DAT"
26555 IF FFC=2 THEN OPEN "I", #1, "A:HPCU2.DAT"
26560 IF FFC=3 THEN OPEN "I", #1, "A:HPCU3.DAT"
```

```
26565 IF FFC=4 THEN OPEN "I", #1, "A:HPCU4.DAT"
26570 IF FFC=5 THEN OPEN "I", #1, "A:HPCU5.DAT"
26575 IF FFC=6 THEN OPEN "I", #1, "A:HPCU6.DAT"
26580 IF FFC=7 THEN OPEN "I", #1, "A:HPCU7.DAT"
26585 IF FFC=8 THEN OPEN "I", #1, "A:HPCU8.DAT"
26590 IF FFC=9 THEN OPEN "I", #1, "A:HPCU9.DAT"
26595 IF FFC=10 THEN OPEN "I", #1, "A:HPCU10.DAT"
26600 REM
26605 FOR C=1 TO 4
26610 FOR B=1 TO 10
26615 INPUT#1, CU3(B,C,1)
26620 NEXT B
26625 NEXT C
26630 FOR D=1 TO 2
26635 FOR C=1 TO 3
26640 FOR B=1 TO 10
26645 INPUT#1, CU4(B,C,D)
26650 NEXT B
26655 NEXT C
26660 NEXT D
26665 REM
26670 CLOSE #1
26675 GOTO 27130
26680 REM
26685 REM
26690 IF ACREF < 80 THEN 26705
26695 D1 = 1  :D2 = 0
26700 GOTO 26790
26705 IF ACREF <= 70 THEN 26720
26710 D1 = 1  :D2 = 2
26715 GOTO 26790
26720 IF ACREF < 70 THEN 26735
26725 D1 = 2  :D2 = 0
26730 GOTO 26790
26735 IF ACREF <= 50 THEN 26750
26740 D1 = 2  :D2 = 3
26745 GOTO 26790
26750 IF ACREF < 50 THEN 26765
26755 D1 = 3  :D2 = 0
26760 GOTO 26790
26765 IF ACREF <= 30 THEN 26780
26770 D1 = 3  :D2 = 4
26775 GOTO 26790
26780 D1 = 4  :D2 = 0
26785 REM
26790 IF ACREF < 70 AND AWREF > 50 THEN AWREF = 50
26795 REM
26800 IF AWREF < 70 THEN 26815
26805 C1 = 1  :C2 = 0
26810 GOTO 26900
26815 IF AWREF <= 50 THEN 26830
26820 C1 = 1  :C2 = 2
26825 GOTO 26900
26830 IF AWREF < 50 THEN 26845
26835 C1 = 2  :C2 = 0
26840 GOTO 26900
26845 IF AWREF <= 30 THEN 26860
26850 C1 = 2  :C2 = 3
26855 GOTO 26900
26860 IF AWREF < 30 THEN 26875
26865 C1 = 3  :C2 = 0
26870 GOTO 26900
26875 IF AWREF <= 10 THEN 26890
26880 C1 = 3  :C2 = 4
26885 GOTO 26900
```

```
26890 C1 = 4  :C2 = 0
26895 REM
26900 IF STTAB = 2 THEN 27890
26905 REM
26910 IF D1 > 2 THEN 27040
26915 ACU(1) = CU1(ARATIO,C1,D1)
26920 BCU(1) = CU1(BRATIO,C1,D1)
26925 IF C2 = 0 THEN 26945
26930 ACU(2) = CU1(ARATIO,C2,D1)
26935 BCU(2) = CU1(BRATIO,C2,D1)
26940 REM
26945 IF D2 = 0 THEN 27505
26950 IF D2 > 2 THEN 26995
26955 ACU(3) = CU1(ARATIO,C1,D2)
26960 BCU(3) = CU1(BRATIO,C1,D2)
26965 IF C2 = 0 THEN 26985
26970 ACU(4) = CU1(ARATIO,C2,D2)
26975 BCU(4) = CU1(BRATIO,C2,D2)
26980 REM
26985 GOTO 27115
26990 REM
26995 D3 = 1  :C3 = C1-1
27000 ACU(3) = CU2(ARATIO,C3,D3)
27005 BCU(3) = CU2(BRATIO,C3,D3)
27010 IF C2 = 0 THEN 27030 ELSE C4 = C2-1
27015 ACU(4) = CU2(ARATIO,C4,D3)
27020 BCU(4) = CU2(BRATIO,C4,D3)
27025 REM
27030 GOTO 27495
27035 REM
27040 D3 = D1-2  :C3 = C1-1
27045 ACU(1) = CU2(ARATIO,C3,D3)
27050 BCU(1) = CU2(BRATIO,C3,D3)
27055 IF C2 = 0 THEN 27075 ELSE C4 = C2-1
27060 ACU(2) = CU2(ARATIO,C4,D3)
27065 BCU(2) = CU2(BRATIO,C4,D3)
27070 REM
27075 IF D2 = 0 THEN 27115 ELSE D4 = D2-2
27080 ACU(3) = CU2(ARATIO,C3,D4)
27085 BCU(3) = CU2(BRATIO,C3,D4)
27090 IF C2 = 0 THEN 27115
27095 ACU(4) = CU2(ARATIO,C4,D4)
27100 BCU(4) = CU2(BRATIO,C4,D4)
27105 REM
27110 REM
27115 GOTO 27495
27120 REM
27125 REM
27130 IF ACREF < 80 THEN 27145
27135 D1 = 1  :D2 = 0
27140 GOTO 27200
27145 IF ACREF <= 50 THEN 27160
27150 D1 = 1  :D2 = 2
27155 GOTO 27200
27160 IF ACREF < 50 THEN 27175
27165 D1 = 2  :D2 = 0
27170 GOTO 27200
27175 IF ACREF <= 10 THEN 27190
27180 D1 = 2  :D2 = 3
27185 GOTO 27200
27190 D1 = 3  :D2 = 0
27195 REM
27200 IF ACREF < 80 AND AWREF > 50 THEN AWREF = 50
27205 REM
27210 IF AWREF < 70 THEN 27225
```

```
27215 C1 = 1  :C2 = 0
27220 GOTO 27310
27225 IF AWREF <= 50 THEN 27240
27230 C1 = 1  :C2 = 2
27235 GOTO 27310
27240 IF AWREF < 50 THEN 27255
27245 C1 = 2  :C2 = 0
27250 GOTO 27310
27255 IF AWREF <= 30 THEN 27270
27260 C1 = 2  :C2 = 3
27265 GOTO 27310
27270 IF AWREF < 30 THEN 27285
27275 C1 = 3  :C2 = 0
27280 GOTO 27310
27285 IF AWREF <= 10 THEN 27300
27290 C1 = 3  :C2 = 4
27295 GOTO 27310
27300 C1 = 4  :C2 = 0
27305 REM
27310 IF STTAB = 2 THEN 27890
27315 REM
27320 IF D1 > 1 THEN 27405
27325 ACU(1) = CU3(ARATIO,C1,D1)
27330 BCU(1) = CU3(BRATIO,C1,D1)
27335 IF C2 = 0 THEN 27355
27340 ACU(2) = CU3(ARATIO,C2,D1)
27345 BCU(2) = CU3(BRATIO,C2,D1)
27350 REM
27355 IF D2 = 0 THEN 27495
27360 D3 = 1  :C3 = C1-1
27365 ACU(3) = CU4(ARATIO,C3,D3)
27370 BCU(3) = CU4(BRATIO,C3,D3)
27375 IF C2 = 0 THEN 27395 ELSE C4 = C2-1
27380 ACU(4) = CU4(ARATIO,C4,D3)
27385 BCU(4) = CU4(BRATIO,C4,D3)
27390 REM
27395 GOTO 27495
27400 REM
27405 D3 = D1-1  :C3 = C1-1
27410 ACU(1) = CU4(ARATIO,C3,D3)
27415 BCU(1) = CU4(BRATIO,C3,D3)
27420 IF C2 = 0 THEN 27440 ELSE C4 = C2-1
27425 ACU(2) = CU4(ARATIO,C4,D3)
27430 BCU(2) = CU4(BRATIO,C4,D3)
27435 REM
27440 IF D2 = 0 THEN 27505 ELSE D4 = D2-1
27445 ACU(3) = CU4(ARATIO,C3,D4)
27450 BCU(3) = CU4(BRATIO,C3,D4)
27455 IF C2 = 0 THEN 27505
27460 ACU(4) = CU4(ARATIO,C4,D4)
27465 BCU(4) = CU4(BRATIO,C4,D4)
27470 REM
27475 IF D1 = 3 THEN D1 = 5
27480 IF D1 = 2 THEN D1 = 3
27485 IF D2 = 3 THEN D2 = 5
27490 IF D2 = 2 THEN D2 = 3
27494 REM
27495 IF ACU(1)=0 THEN ACU(1)=ACU(2)
27496 IF BCU(1)=0 THEN BCU(1)=BCU(2)
27497 IF ACU(2)=0 THEN ACU(2)=ACU(1)
27498 IF BCU(2)=0 THEN BCU(2)=BCU(1)
27499 IF ACU(3)=0 THEN ACU(3)=ACU(4)
27500 IF BCU(3)=0 THEN BCU(3)=BCU(4)
27501 IF ACU(4)=0 THEN ACU(4)=ACU(3)
27502 IF BCU(4)=0 THEN BCU(4)=BCU(3)
```

```
27502 REM
27505 IF C2 = 0 THEN 27555
27510 ACUA = ACU(1)-(((ACU(1)-ACU(2))/(PWR(C1)-PWR(C2)))*(PWR(C1)-AWREF))
27515 BCUA = BCU(1)-(((BCU(1)-BCU(2))/(PWR(C1)-PWR(C2)))*(PWR(C1)-AWREF))
27520 REM
27525 IF D2 = 0 THEN 27595
27530 ACUB = ACU(3)-(((ACU(3)-ACU(4))/(PWR(C1)-PWR(C2)))*(PWR(C1)-AWREF))
27535 BCUB = BCU(3)-(((BCU(3)-BCU(4))/(PWR(C1)-PWR(C2)))*(PWR(C1)-AWREF))
27540 REM
27545 GOTO 27575
27550 REM
27555 IF D2 = 0 THEN 27615
27560 ACUA = ACU(1)  :BCUA = BCU(1)
27565 ACUB = ACU(3)  :BCUB = BCU(3)
27570 REM
27575 ACUC = ACUA-(((ACUA-ACUB)/(PCR(D1)-PCR(D2)))*(PCR(D1)-ACREF))
27580 BCUC = BCUA-(((BCUA-BCUB)/(PCR(D1)-PCR(D2)))*(PCR(D1)-ACREF))
27585 REM
27590 GOTO 27625
27595 ACUC = ACUA  :BCUC = BCUA
27600 GOTO 27625
27605 REM
27610 REM
27615 ACUC = ACU(1)  :BCUC = BCU(1)
27620 REM
27625 CCUC = ACUC-((ACUC-BCUC)*(RCAVRAT-ARATIO))
27626 IF CCUC=0 THEN 27628
27627 GOTO 27640
27628 CLS :PRINT :PRINT :PRINT :PRINT :PRINT :PRINT TAB(10);
27629 PRINT "Not enough CU values are available, please update fixture file"
27630 PRINT TAB(10 "with additional CU values for a ceiling reflectance of: ";
27631 PRINT PCR(D1); ","
27632 PRINT TAB(10) "and a wall reflectance of: "; PWR(C1); "."
27633 PRINT :PRINT :PRINT TAB(10);
27634 INPUT "          Press -RETURN- to return to menu. "; B$
27635 GOTO 5140
27636 REM
27637 REM
27640 REM ****************** FLOOR COEFFICIENT
27645 REM
27650 REM
27655 IF AFREF = 20 THEN KOEF = 1 ELSE 27670
27660 GOTO 27800
27665 REM
27670 IF PCR(D1)=80 THEN OPEN "I", #1, "A:FMULFAC8.FLR"
27675 IF PCR(D1)=70 THEN OPEN "I", #1, "A:FMULFAC7.FLR"
27680 IF PCR(D1)=50 THEN OPEN "I", #1, "A:FMULFAC5.FLR"
27685 IF PCR(D1)=30 THEN OPEN "I", #1, "A:FMULFAC3.FLR"
27690 IF PCR(D1)=10 THEN OPEN "I", #1, "A:FMULFAC1.FLR"
27695 REM
27700 FOR A=1 TO 3
27705 FOR B=1 TO 20
27710 INPUT #1, MFACTOR(A,B)
27715 NEXT B
27720 NEXT A
27725 CLOSE#1
27730 REM
27735 C5 = C1
27740 IF C5=4 THEN C5=3
27745 REM
27750 IF AFREF = 20 THEN KOEF = MFACTOR(C5,3RATIO) ELSE 27765
27755 GOTO 27800
27760 REM
27765 IF AFREF < 20 THEN 27785
27770 KOEF = MFACTOR(C5,3RATIO)-((MFACTOR(C5,3RATIO)-1) / 3 *(20-AFREF))
```

```
27775 GOTO 27800
27780 REM
27785 KOEF = 1-(((1-MFACTOR(C5,BRATIO+10))/20)*(20-AFREF))
27790 REM
27795 REM
27800 REM ****************** FINAL CU VALUE
27805 REM
27810 REM
27815 FCU = CCUC * KOEF
27820 FINALCU = FCU / 100
27825 REM
27830 RETURN
27835 REM
27840 REM
27845 REM ****************** NON-STORED CU TABLES
27850 REM
27855 REM
27860 IF SOL = 1 THEN 26690
27865 IF SOL = 2 THEN 26690
27870 IF SOL = 3 THEN 27170
27875 IF SOL = 4 THEN 27130
27880 IF SOL = 5 THEN 27130
27885 REM
27890 IF SOL = 1 OR SOL = 2 THEN 27920
27895 IF D1 = 3 THEN D1 = 5
27900 IF D1 = 2 THEN D1 = 3
27905 IF D2 = 3 THEN D2 = 5
27910 IF D2 = 2 THEN D2 = 3
27915 REM
27920 CLS
27925 PRINT TAB(5) "Critical";
27930 PRINT TAB(20) "PFR"; TAB(26) ":"; TAB(30) PFR(C)
27935 PRINT TAB(5) "CU";
27940 PRINT TAB(20) "FCR"; TAB(26) ":"; TAB(30) FCR(D1);
27945 IF D2 > 0 THEN PRINT TAB(55) FCR(D2);
27950 PRINT ""
27955 PRINT TAB(5) "Values";
27960 PRINT TAB(20) "PWR"; TAB(26) ":"; TAB(30) PWR(C1);
27965 IF C2 > 0 THEN PRINT TAB(40) PWR(C2);
27970 IF D2 > 0 THEN PRINT TAB(55) PWR(C1); ELSE 27980
27975 IF C2 > 0 THEN PRINT TAB(65) PWR(C2);
27980 PRINT ""
27985 PRINT TAB(20) "RCR"; TAB(26) ":"
27990 PRINT TAB(20) "------;----------------------------------------"
27995 PRINT TAB(26) ":"
28000 AA=1
28005 PRINT TAB(20) ARATIO; TAB(26) ":"; TAB(29) "("; AA; ")";
28010 AA = AA + 1
28015 IF C2 > 0 THEN PRINT TAB(39) "("; AA; ")"; ELSE 28025
28020 AA = AA + 1
28025 IF D2 > 0 THEN PRINT TAB(54) "("; AA; ")"; ELSE 28045
28030 AA = AA + 1
28035 IF C2 > 0 THEN PRINT TAB(64) "("; AA; ")"; ELSE 28045
28040 AA = AA + 1
28045 PRINT ""
28050 IF E1=1 THEN 28100
28055 PRINT TAB(26) ":"
28060 PRINT TAB(20) BRATIO; TAB(26) ":"; TAB(29) "("; AA; ")";
28065 AA = AA + 1
28070 IF C2 > 0 THEN PRINT TAB(39) "("; AA; ")"; ELSE 28080
28075 AA = AA + 1
28080 IF D2 > 0 THEN PRINT TAB(54) "("; AA; ")"; ELSE 28095
28085 AA = AA + 1
28090 IF C2 > 0 THEN PRINT TAB(64) "("; AA; ")";
28095 PRINT ""
```

```
28100 PRINT :PRINT :PRINT TAB(5);
28105 PRINT "Please enter the following values from the Fixture & CU chart"
28106 PRINT TAB(5);
28110 PRINT "to fill in the chart above.  If value is not given on Fixture &"
28111 PRINT TAB(5);
28112 PRINT "CU chart, enter 0 , or do manual extrapolation and enter value."
28115 PRINT :PRINT
28120 BB=1
28125 PRINT TAB(30) "("; BB; ")  "; :INPUT ACU(1)
28130 IF C2 > 0 THEN BB=BB+1 ELSE 28140
28135 PRINT TAB(30) "("; BB; ")  "; :INPUT ACU(2)
28140 IF D2 > 0 THEN BB=BB+1 ELSE 28165
28145 PRINT TAB(30) "("; BB; ")  "; :INPUT ACU(3)
28150 IF C2 > 0 THEN BB=BB+1 ELSE 28165
28155 PRINT TAB(30) "("; BB; ")  "; :INPUT ACU(4)
28160 IF E1=1 THEN 28210
28165 BB=BB+1
28170 PRINT TAB(30) "("; BB; ")  "; :INPUT BCU(1)
28175 IF C2 > 0 THEN BB=BB+1 ELSE 28185
28180 PRINT TAB(30) "("; BB; ")  "; :INPUT BCU(2)
28185 IF D2 > 0 THEN BB=BB+1 ELSE 28210
28190 PRINT TAB(30) "("; BB; ")  "; :INPUT BCU(3)
28195 IF C2 > 0 THEN BB=BB+1 ELSE 28210
28200 PRINT TAB(30) "("; BB; ")  "; :INPUT BCU(4)
28205 REM
28210 CLS :PRINT :PRINT
28215 PRINT TAB(20) "Please check:"
28220 PRINT :PRINT :PRINT
28225 PRINT TAB(15) "Critical CU Values from the Fixture Chart"
28230 PRINT
28235 PRINT TAB(20) "PFR"; TAB(26) "!"; TAB(30) PFR(2)
28240 PRINT TAB(20) "PCR"; TAB(26) "!"; TAB(30) PCR(D1);
28245 IF D2 > 0 THEN PRINT TAB(55) PCR(D2);
28250 PRINT ""
28255 PRINT TAB(20) "PWR"; TAB(26) "!"; TAB(30) PWR(C1);
28260 IF C2 > 0 THEN PRINT TAB(40) PWR(C2);
28265 IF D2 > 0 THEN PRINT TAB(55) PWR(C1); ELSE 28275
28270 IF C2 > 0 THEN PRINT TAB(65) PWR(C2);
28275 PRINT ""
28280 PRINT TAB(20) "RCR"; TAB(26) "!"
28285 PRINT TAB(20) "------!----------------------------------------"
28290 PRINT TAB(26) "!"
28295 PRINT TAB(19) ARATIO; TAB(26) "!"; TAB(30) ACU(1);
28300 IF C2 > 0 THEN PRINT TAB(40) ACU(2);
28305 IF D2 > 0 THEN PRINT TAB(55) ACU(3); ELSE 28315
28310 IF C2 > 0 THEN PRINT TAB(65) ACU(4);
28315 PRINT ""
28320 IF E1=1 THEN 28355
28325 PRINT TAB(26) "!"
28330 PRINT TAB(19) BRATIO; TAB(26) "!"; TAB(30) BCU(1);
28335 IF C2 > 0 THEN PRINT TAB(40) BCU(2);
28340 IF D2 > 0 THEN PRINT TAB(55) BCU(3); ELSE 28350
28345 IF C2 > 0 THEN PRINT TAB(65) BCU(4);
28350 PRINT ""
28355 PRINT :PRINT :PRINT :PRINT
28360 INPUT "                    Is everything correct (Y/N) "; B$
28365 IF B$="N" OR B$="n" THEN 28375
28370 GOTO 27495
28375 PRINT :PRINT
28380 INPUT "       Please re-enter CU values, press <RETURN> when ready ", B$
28385 GOTO 27920
29100 REM ****************** NUMBER OF FIXTURES *********************************
29105 REM
29110 REM
29115 NUMFIX = (FCLEVEL*RMFAREA)/(INITLUM*LQUANT*FINALCU*LLF)
```

```
29120 REM
29125 RETURN
29130 REM
29135 REM
30100 REM ****************** ACTUAL FC LEVEL ***********************************
30105 REM
30110 REM
30115 ACTFCMAIN = (ACTFIXNUM*FINALCU*LLF*INITLUM*LQUANT)/RMFAREA
30120 REM
30125 REM
30130 ACTFCINIT = ACTFCMAIN/LLF
30135 REM
30140 REM
30145 REM ****************** SPACING CRITERIA
30150 REM
30155 SPCCRIT = STMHRAT*(FTFHGT-FTWSHGT)
30160 REM
30165 RETURN
30170 REM
30175 REM
40100 REM ****************** ROOM REFERENCE DATA ******************************
40105 REM
40110 REM
40115 CLS :PRINT :PRINT
40120 INPUT "              Please enter the building number: ", BLDG$
40125 PRINT :PRINT
40130 INPUT "              Please enter room number:         ", ROOM$
40135 PRINT :PRINT
40140 PRINT "      This is Iteration #"; ITERATE; " for this room";
40145 INPUT " -- Correct (Y/N) "; B$
40150 IF B$="N" OR B$="n" THEN 40160
40155 RETURN
40160 PRINT :PRINT :PRINT
40165 INPUT "              Please enter Iteration # ", ITERATE
40170 GOTO 40155
40175 REM
40180 REM
41100 REM ****************** 88-15 FOOTCANDLE LEVELS **************************
41105 REM
41110 REM
41115 CLS
41120 PRINT :PRINT :PRINT
41125 PRINT TAB(25) "FOOTCANDLE LEVEL REQUIREMENTS"
41130 PRINT :PRINT :PRINT
41135 PRINT TAB(12) "You must select the room's actual use along with its"
41140 PRINT TAB(12) "corresponding FC level from the following table.  This"
41145 PRINT TAB(12) "table comes from the AFR 88-15, and is split into three"
41150 PRINT TAB(12) "screens.  To enter your own FC level, choose #1 on the"
41155 PRINT TAB(12) "first screen."
41160 PRINT :PRINT :PRINT :PRINT TAB(26);
41165 INPUT "Press  <RETURN>  to continue.", B$
41170 B=1 :D=0
41175 CLS
41180 CLS
41185 PRINT ,"ROOM TYPE","ROOM USE          ","FC LEVEL"
41190 PRINT
41195 FOR A=B TO (B+11)
41200 PRINT ,A,RMUSE$(A),RMUSELEVEL(A)
41205 NEXT A
41210 PRINT :PRINT ,(B+12),"OTHER"
41215 PRINT :PRINT : INPUT "          Enter selected Room Type:     ", RMTYPE
41220 IF RMTYPE > (B-1) AND RMTYPE < (B+12) THEN 41255
41225 IF RMTYPE > 37 THEN 41325
41230 IF D=1 OR D=2 THEN 41240
41235 B=13 :D=1 :GOTO 41175
```

```
41240 IF B=2 THEN 41250
41245 B=25 :D=2 :GOTO 41175
41250 B=1 :D=0 :GOTO 41175
41255 IF RMTYPE = 1 THEN 41245
41260 FCLEVEL=RMUSELEVEL(RMTYPE) :ROOMUSE$=RMUSE$(RMTYPE)
41265 CLS :PRINT :PRINT :PRINT :PRINT
41270 PRINT TAB(20) "You have chosen:              ", ROOMUSE$
41275 PRINT
41280 PRINT TAB(20) "With a footcandle level of:  ", FCLEVEL
41285 PRINT :PRINT TAB(20);
41290 INPUT "Is this correct (Y/N) "; B$
41295 IF B$="N" OR B$="n" THEN 41305
41300 RETURN
41305 PRINT :PRINT :PRINT TAB(12);
41310 INPUT "Please select again,  press  <RETURN>  when ready.", B$
41315 GOTO 41170
41320 REM
41325 CLS :PRINT :PRINT :PRINT :PRINT :PRINT :PRINT
41330 PRINT TAB(15);
41335 INPUT "Invalid entry.  press  RETURN  to try again.", B$
41340 GOTO 41170
41345 CLS :PRINT :PRINT :PRINT
41350 INPUT "              Please indicate desired FC level: ", FCLEVEL
41355 ROOMUSE$ = RMUSE$(RMTYPE)
41360 GOTO 41265
41365 REM
41370 REM
42100 REM ***************** ROOM DIMENSION INFORMATION **********************
42105 REM                   ROOM CAVITY RATIO CALCULATIONS.
42110 REM
42115 CLS :PRINT :PRINT :PRINT :PRINT
42120 PRINT TAB(20) "ROOM DIMENSIONS"
42125 PRINT :PRINT
42130 PRINT TAB(15) "To calculate the cavity ratios of the room,"
42135 PRINT TAB(15) "either the room length and width must be"
42140 PRINT TAB(15) "used, or the room perimeter and floor area"
42145 PRINT TAB(15) "must be used."
42150 PRINT :PRINT :PRINT :PRINT
42155 PRINT TAB(10) "Which will you be using to calculate the cavity ratios?"
42160 PRINT
42165 PRINT TAB(10) "Enter (1) for length and width measurements."
42170 PRINT TAB(10) "      (2) for perimeter and area measurements."
42175 PRINT TAB(10);
42180 INPUT "     "; B
42185 CLS
42190 PRINT :PRINT
42195 PRINT TAB(10) "Enter the following room dimensions (in feet):"
42200 PRINT :PRINT :PRINT
42205 IF B=2 THEN 42225
42210 INPUT "          Room Length:                    "; RMLGTH
42215 INPUT "          Room Width:                     "; RMWDTH
42220 GOTO 42235
42225 INPUT "          Room Perimeter:                 "; RMPER
42230 INPUT "          Room Floor Area:                "; RMFAREA
42235 PRINT
42240 INPUT "          Floor To Ceiling Height:        "; FTCHGT
42245 INPUT "          Floor To Fixture Height:        "; FTFHGT
42250 INPUT "          Floor To Working Surface Height: "; FTWSHGT
42255 REM
42260 IF B=2 THEN 42285
42265 RMPER = 2 * (RMLGTH+RMWDTH)
42270 RMFAREA = RMLGTH * RMWDTH
42275 REM
42280 IF FTCHGT < 0 OR FTFHGT < 0 THEN 42420
42285 FCAVHGT = FTCHGT - FTFHGT
```

```
42290 IF TCAVHGT < 0 THEN 42420
42295 RCAVHGT = FTFHGT - FTWSHGT
42300 IF RCAVHGT < 0 THEN 42420
42305 FCAVHGT = FTWSHGT
42310 IF FCAVHGT < 0 THEN 42420
42315 REM
42320 TCAVRAT = (2.5 * (TCAVHGT * RMPER)) / RMFAREA
42325 RCAVRAT = (2.5 * (RCAVHGT * RMPER)) / RMFAREA
42330 FCAVRAT = (2.5 * (FCAVHGT * RMPER)) / RMFAREA
42335 REM
42340 CLS :PRINT :PRINT :PRINT
42345 PRINT "          Please verify the following information:"
42350 PRINT :PRINT
42355 IF B=2 THEN 42370
42360 PRINT TAB(15) "The Room Length:                    "; RMLGTH; "ft."
42365 PRINT TAB(15) "The Room Width:                     "; RMWDTH; "ft."
42370 PRINT TAB(15) "The Room Perimeter:                 "; RMPER; "ft."
42375 PRINT TAB(15) "The Room Floor Area:                "; RMFAREA; "ft^2"
42380 PRINT
42385 PRINT TAB(15) "The Floor to Ceiling Height:        "; FTCHGT; "ft."
42390 PRINT TAB(15) "The Floor to Fixture Height:        "; FTFHGT; "ft."
42395 PRINT TAB(15) "The Floor to Working Surface Height: "; FTWSHGT; "ft."
42400 PRINT :PRINT
42405 INPUT "          Is everything correct (Y/N) "; B$
42410 IF B$="n" OR B$="N" THEN 42485
42415 RETURN
42420 CLS
42425 PRINT :PRINT :PRINT :PRINT TAB(5);
42430 PRINT "Please ensure that your numbers fit the following requirements:"
42435 PRINT :PRINT TAB(8);
42440 PRINT "(1) Fixture height must be equal to or less than Ceiling height:"
42445 PRINT TAB(8);
42450 PRINT "(2) Working surface cannot be above Fixture height; and"
42455 PRINT TAB(8);
42460 PRINT "(3) No surface height can be less than zero."
42465 PRINT
42470 PRINT TAB(5) "Please enter the height dimensions again: "
42475 PRINT :PRINT
42480 GOTO 42235
42485 PRINT :PRINT :PRINT TAB(11);
42490 INPUT "Please re-enter data.  press <RETURN> when ready.", B$
42495 GOTO 42185
42500 REM
42505 REM
43100 REM ****************** SURFACE REFLECTANCES ****************************
43105 REM
43110 REM
43115 CLS :PRINT :PRINT :PRINT
43120 PRINT TAB(30) "SURFACE REFLECTANCES"
43125 PRINT :PRINT :PRINT
43130 PRINT TAB(12) "You need to choose the color and reflectance ratings"
43135 PRINT TAB(12) "of the ceiling, the walls, and the floor.  Following"
43140 PRINT TAB(12) "are 3 screens full of colors and their associated"
43145 PRINT TAB(12) "reflectances to make your choices from.  Please enter"
43150 PRINT TAB(12) "the TYPE # in the sequence indicated."
43155 PRINT :PRINT :PRINT TAB(26);
43160 INPUT "Press <RETURN> to continue.", B$
43165 REM
43170 B=1 :C=0 :D=0
43175 CLS :PRINT
43180 PRINT ,"TYPE","BRAND","COLOR","REFLECTIVITY"
43185 PRINT
43190 FOR A=B TO (B+9)
43195 PRINT ,A, PTMAN$(A), PTCOLOR$(A); TAB(60) PTREFL(A)
43200 NEXT A
```

```
43205 PRINT :PRINT ,(B+10), "OTHER"
43210 PRINT :PRINT
43215 PRINT ,"To select, Enter TYPE #"
43220 PRINT
43225 IF C=1 GOTO 43275
43230 IF C=2 GOTO 43325
43235 INPUT "              TYPE # for Ceiling Color:          ", CLREF
43240 IF CLREF > (B-1) AND CLREF < (B+10) THEN 43280
43245 IF CLREF > 31 THEN 43490
43250 IF D=1 OR D=2 THEN 43260
43255 B=11 :D=1 :GOTO 43175
43260 IF D=2 THEN 43270
43265 B=21 :D=2 :GOTO 43175
43270 B=1 :D=0 :GOTO 43175
43275 PRINT TAB(15) "TYPE # for Ceiling Color:         "; CLREF
43280 C=2
43285 INPUT "              TYPE # for Wall Color:            ", WLREF
43290 IF WLREF > (B-1) AND WLREF < (B+10) THEN 43335
43295 IF WLREF > 31 THEN 43490
43300 IF D=1 OR D=2 THEN 43310
43305 B=11 :D=1 :GOTO 43175
43310 IF D=2 THEN 43320
43315 B=21 :D=2 :GOTO 43175
43320 B=1 :D=0 :GOTO 43175
43325 PRINT TAB(15) "TYPE # for Ceiling Color:         "; CLREF
43330 PRINT TAB(15) "TYPE # for Wall Color:           "; WLREF
43335 C=2
43340 INPUT "              TYPE # for Floor Color:           ", FLREF
43345 IF FLREF > (B-1) AND FLREF < (B+10) THEN 43380
43350 IF FLREF > 31 THEN 43490
43355 IF D=1 OR D=2 THEN 43365
43360 B=11 :D=1 :GOTO 43175
43365 IF D=2 THEN 43375
43370 B=21 :D=2 :GOTO 43175
43375 B=1 :D=0 :GOTO 43175
43380 REM
43385 CLS :PRINT :PRINT
43390 PRINT TAB(10) "You have chosen:"
43395 PRINT :PRINT
43400 PRINT TAB(10) PTCOLOR$(CLREF); TAB(30) "with a"; PTREFL(CLREF);
43405 PRINT "%  Reflectivity for the Ceiling."
43410 PRINT
43415 PRINT TAB(10) PTCOLOR$(WLREF); TAB(30) "with a"; PTREFL(WLREF);
43420 PRINT "%  Reflectivity for the Walls."
43425 PRINT
43430 PRINT TAB(10) PTCOLOR$(FLREF); TAB(30) "with a"; PTREFL(FLREF);
43435 PRINT "%  Reflectivity for the Floor."
43440 PRINT :PRINT :PRINT
43445 INPUT "         Are these all correct (Y/N) "; B$
43450 IF B$="N" OR B$="n" THEN 43475
43455 CEILREF = PTREFL(CLREF) :CLCOLOR$ = PTCOLOR$(CLREF)
43460 WALLREF = PTREFL(WLREF) :WLCOLOR$ = PTCOLOR$(WLREF)
43465 FLOOREF = PTREFL(FLREF) :FLCOLOR$ = PTCOLOR$(FLREF)
43470 RETURN
43475 PRINT :PRINT :PRINT TAB(10);
43480 INPUT "Please re-enter you choices,  press  <RETURN>  to continue.", B$
43485 GOTO 43165
43490 CLS :PRINT :PRINT :PRINT :PRINT :PRINT :PRINT
43495 PRINT TAB(12);
43500 INPUT "Invalid entry,  press  <RETURN>  to try again.", B$
43505 GOTO 43175
43510 REM
43515 REM
44100 REM ****************** ROOM DIRT CONDITIONS ****************************
44105 REM
```

```
44110 REM
44115 CLS :PRINT :PRINT :PRINT
44120 PRINT TAB(30) "ROOM DIRT CONDITIONS"
44125 PRINT :PRINT :PRINT
44130 PRINT TAB(23) "You must select a  Dirt Condition ,"
44135 PRINT TAB(23) "and a cleaning cycle for the room."
44140 PRINT :PRINT :PRINT :PRINT TAB(26);
44145 INPUT "Press  <RETURN>  to continue.", B$
44150 CLS :PRINT :PRINT
44155 PRINT ,"DEGREES OF ROOM DIRT CONDITION"
44160 PRINT :PRINT
44165 PRINT ,"DEGREE","EXAMPLE","CONDITION"
44170 PRINT
44175 B=6
44180 FOR A=1 TO 5
44185 PRINT ,A,B,RMDTCD$(A,1)
44190 B=B+1
44195 NEXT A
44200 PRINT :PRINT
44205 PRINT "     Enter DEGREE #  to select condition or,"
44210 PRINT "           EXAMPLE # to see explaination of condition."
44215 PRINT :PRINT
44220 INPUT "     Selection: ", C
44225 REM
44230 IF C < 1 OR C > 10 THEN 44455
44235 IF C > 0 AND C < 6 THEN 44345
44240 IF C > 5 AND C < 11 THEN 44265
44245 PRINT :PRINT
44250 INPUT "     Invalid entry,  press  <RETURN>  to try again.", B$
44255 GOTO 44140
44260 REM
44265 CLS :PRINT
44270 PRINT TAB(10) "CONDITION :   ", RMDTCD$(C-5,1)
44275 PRINT :PRINT
44280 PRINT ,"GENERATED DIRT", RMDTCD$(C-5,2)
44285 PRINT
44290 PRINT ,"AMBIENT DIRT  ", RMDTCD$(C-5,3)
44295 PRINT
44300 PRINT ,"REMOVAL OR    ", RMDTCD$(C-5,4)
44305 PRINT ,"FILTRATION"
44310 PRINT
44315 PRINT ,"ADHESION      ", RMDTCD$(C-5,5)
44320 PRINT
44325 PRINT ,"EXAMPLES      ", RMDTCD$(C-5,6)
44330 PRINT :PRINT :PRINT :PRINT :PRINT TAB(10);
44335 INPUT "Press  <RETURN>  when ready to continue.", B$
44340 GOTO 44150
44345 REM
44350 DIRTCD$ = RMDTCD$(C,1)
44355 REM
44360 PRINT
44365 PRINT "     Please indicate the normal time between fixture cleaning."
44370 PRINT "     Example:  Cleaned once every three years  =  36 months."
44375 PRINT
44380 INPUT "     Your cleaning cycle time (in months)"; CLCYCLE
44385 CLS :PRINT :PRINT :PRINT :PRINT :PRINT
44390 PRINT TAB(20) "You have chosen:"
44395 PRINT :PRINT
44400 PRINT TAB(20) "A Room Dirt Condition of:  " DIRTCD$
44405 PRINT
44410 PRINT TAB(20) "and a Cleaning Cycle of:   " CLCYCLE; " months"
44415 PRINT :PRINT :PRINT :PRINT TAB(15);
44420 INPUT "Are these correct (Y/N)"; B$
44425 IF B$="N" OR B$="n" THEN 44435
44430 RETURN
```

```
44435 PRINT :PRINT
44440 PRINT :PRINT TAB(15);
44445 INPUT "Please re-enter data,  press  <RETURN>  when ready.", B$
44450 GOTO 44150
44455 PRINT :PRINT
44460 INPUT "     Invalid entry,  press  <RETURN>  to try again. ", B$
44465 GOTO 44150
44470 REM
44475 REM
45100 REM ****************** LIGHT SOURCE TYPES *******************************
45105 REM
45110 REM
45115 CLS
45120 PRINT :PRINT
45125 PRINT TAB(32) "LIGHT SOURCE CHOICES"
45130 PRINT :PRINT :PRINT
45135 PRINT TAB(20) "CHOICE" TAB(40) "LIGHT SOURCE TYPE"
45140 PRINT :PRINT
45145 FOR A=1 TO 5
45150 PRINT TAB(22) A; TAB(40) SOURCE$(A,1); TAB(62) "("; SOURCE$(A,2); ")"
45155 NEXT A
45160 PRINT :PRINT
45165 INPUT "     Enter CHOICE # for source selection: ", SOL
45170 IF SOL < 1 OR SOL > 5 GOTO 45200
45175 REM
45180 PRINT :PRINT
45185 INPUT "     Do you want to use a fixture stored in memory (Y/N) "; B$
45190 IF B$="n" OR B$="N" THEN STTAB=2 ELSE STTAB=1
45195 RETURN
45200 REM
45205 PRINT :PRINT
45210 INPUT "     Invalid entry,  press  <RETURN>  to try again.", B$
45215 GOTO 45115
45220 REM
45225 REM
47100 REM ****************** FIXTURE CHOICES *********************************
47105 REM
47110 REM
47115 CLS
47120 PRINT TAB(21) "FIXTURE CHOICES:  "; SOURCE$(SOL,1); " Fixtures"
47125 PRINT :PRINT :PRINT
47130 PRINT "CHOICE"; TAB(12) "FILE #"; TAB(23) "MAKE"; TAB(37) "MODEL #";
47135 PRINT TAB(51) "MAINT."; TAB(64) "DIST."; TAB(74) "S/MH"
47140 PRINT TAB(50) "CATEGORY"; TAB(64) "TYPE"
47145 PRINT :PRINT
47150 FOR A=1 TO 10
47155 PRINT TAB(3) A; TAB(12) FCODE$(SOL,A,1); TAB(23) FCODE$(SOL,A,2);
47160 PRINT TAB(37) FCODE$(SOL,A,3); TAB(53) FCODE$(SOL,A,4);
47165 PRINT TAB(65) FIXTDATA(SOL,A,2); TAB(74) FIXTDATA(SOL,A,1)
47170 NEXT A
47175 PRINT :PRINT
47180 PRINT "     Enter CHOICE # to choose fixture, or"
47181 INPUT "          (0) to choose different light source type:  ", FFC
47185 IF FFC < 0 OR FFC > 10 GOTO 47360
47186 IF FFC = 0 THEN RETURN
47190 REM
47195 REM
47200 CLS
47205 PRINT :PRINT
47210 PRINT TAB(20) "FIXTURE CHOICES:  "; SOURCE$(SOL,1); " Fixtures"
47215 PRINT :PRINT
47220 PRINT TAB(10) "You have chosen:"
47225 PRINT
47230 PRINT TAB(20) "Fixture Make:"; TAB(55) FCODE$(SOL,FFC,2)
47235 PRINT
```

```
47240 PRINT TAB(20) "Fixture Model:"; TAB(55) FCODE$(SOL,FFC,3)
47245 PRINT
47250 PRINT TAB(20) "Fixture's Maintenance Category:"; TAB(55) FCODE$(SOL,FFC,4)
47255 PRINT
47260 PRINT TAB(20) "Fixture's Distribution Type:"; TAB(55) FIXTDATA(SOL,FFC,2)
47265 PRINT
47270 PRINT TAB(20) "Fixture's S/MH Ratio:"; TAB(55) FIXTDATA(SOL,FFC,1)
47275 PRINT :PRINT
47280 INPUT "          Are these correct (Y/N) "; B$
47285 IF B$="N" OR B$="n" GOTO 47335
47290 REM
47295 FIXTFILE$ = FCODE$(SOL,FFC,1)
47300 FIXTMAKE$ = FCODE$(SOL,FFC,2)
47305 FIXTMODEL$ = FCODE$(SOL,FFC,3)
47310 MAINCAT$ = FCODE$(SOL,FFC,4)
47315 STMHRAT = FIXTDATA(SOL,FFC,1)
47320 DISTTYP = FIXTDATA(SOL,FFC,2)
47325 REM
47330 RETURN
47335 PRINT
47340 INPUT "          Please choose again, press <RETURN> when ready.", B$
47345 GOTO 47115
47350 REM
47355 REM
47360 PRINT
47365 INPUT "     Invalid entry, press <RETURN> to try again. ", B$
47370 GOTO 47115
47375 REM
47380 REM
48100 REM ****************** LAMP CHOICES ************************************
48105 REM
48110 REM
48115 CLS
48120 PRINT TAB(21) "LAMP CHOICES:  "; SOURCE$(SOL,1); " Lamps"
48125 PRINT :PRINT
48130 PRINT TAB(8) "CHOICE"; TAB(19) "FILE #"; TAB(31) "CODE";
48135 PRINT TAB(43) "WATTS"; TAB(55) "INITIAL"; TAB(68) "MAINT."
48140 PRINT TAB(55) "LUMENS"; TAB(68) "LUMENS"
48145 PRINT
48150 FOR A=1 TO 10
48155 PRINT TAB(10) A; TAB(19) LCODE$(SOL,A,1); TAB(30) LCODE$(SOL,A,2);
48160 PRINT TAB(43) LAMPDATA(SOL,A,1); TAB(55) LAMPDATA(SOL,A,2);
48165 PRINT TAB(68) LAMPDATA(SOL,A,3)
48170 NEXT A
48175 PRINT :PRINT
48180 INPUT "     To select a lamp, enter CHOICE # ", LLC
48185 IF LLC < 1 OR LLC > 10 GOTO 48375
48190 PRINT
48195 INPUT "     How many lamps are required per fixture"; LAMPNUM
48200 IF LAMPNUM < 1 THEN 48375
48205 REM
48210 CLS
48215 PRINT :PRINT
48220 PRINT TAB(10) "You have chosen:"
48225 PRINT :PRINT
48230 PRINT "               Lamp Type:              "; SOURCE$(SOL,1)
48235 PRINT
48240 PRINT "               Lamp File #             "; LCODE$(SOL,LLC,1)
48245 PRINT
48250 PRINT "               Lamp Code:              "; LCODE$(SOL,LLC,2)
48255 PRINT
48260 PRINT "               Lamp Watts:             "; LAMPDATA(SOL,LLC,1)
48265 PRINT
48270 PRINT "               Lamp's Initial Lumens:  "; LAMPDATA(SOL,LLC,2)
48275 PRINT
```

```
48280 PRINT "              Lamp's Maintained Lumens: "; LAMPDATA(SOL,LLC,3)
48285 PRINT
48290 PRINT "              Lamps per Fixture:        "; LAMPNUM
48295 PRINT :PRINT
48300 INPUT "        Is everything correct (Y/N) "; B$
48305 IF B$="N" OR B$="n" GOTO 48315
48310 GOTO 48335
48315 PRINT :PRINT
48320 INPUT "        Please choose again,  press  <RETURN>  when ready. ", B$
48325 GOTO 48115
48330 REM
48335 LAMPFILE$ = LCODE$(SOL,LLC,1)
48340 LQUANT = LAMPNUM
48345 LWATTS = LAMPDATA(SOL,LLC,1)
48350 INITLUM = LAMPDATA(SOL,LLC,2)
48355 MAINTLUM = LAMPDATA(SOL,LLC,3)
48360 LTYPE$ = LCODE$(SOL,LLC,2)
48365 RETURN
48370 REM
48375 PRINT :PRINT
48380 INPUT "     Invalid entry,  press  <RETURN>  to try again. ", B$
48385 GOTO 48115
48390 REM
48395 REM
50100 REM ****************** NON-TABLED ROOM INFORMATION **********************
50105 REM
50110 REM
50115 REM ****************** ROOM USE W/O TABLES
50120 CLS
50125 PRINT :PRINT :PRINT :PRINT :PRINT
50130 INPUT "          Please enter the room's use:              ", ROOMUSE$
50135 PRINT
50140 INPUT "          Please enter the FC level required:       ", FCLEVEL
50145 PRINT :PRINT :PRINT :PRINT
50150 INPUT "          Is everything correct (Y/N) "; B$
50155 IF B$="N" OR B$="n" THEN 50165
50160 RETURN
50165 PRINT :PRINT :PRINT
50170 INPUT "          Re-enter data.       Press  <RETURN>  when ready.", B$
50175 GOTO 50120
50180 REM
50185 REM
50190 REM ****************** ROOM REFLECTANCES W/O TABLES
50195 CLS
50200 PRINT :PRINT :PRINT
50205 INPUT "     Please enter the Ceiling Color:                    ", CLCOLOR$
50210 INPUT "     Please enter the Ceiling Reflectance (no decimal): ", CEILREF
50215 PRINT
50220 INPUT "     Please enter the Wall Color:                       ", WLCOLOR$
50225 INPUT "     Please enter the Wall Reflectance (no decimal):    ", WALLREF
50230 PRINT
50235 INPUT "     Please enter the Floor Color:                      ", FLCOLOR$
50240 INPUT "     Please enter the Floor Reflectance (no decimal):   ", FLOOREF
50245 PRINT :PRINT :PRINT
50250 INPUT "     Is everything correct (Y/N) "; B$
50255 IF B$="N" OR B$="n" THEN 50290
50260 IF CEILREF < 1 OR CEILREF > 100 THEN 50280
50265 IF WALLREF < 1 OR WALLREF > 100 THEN 50280
50270 IF FLOOREF < 1 OR FLOOREF > 100 THEN 50280
50275 RETURN
50280 PRINT :PRINT
50285 PRINT "     Reflectances must be greater than one and less than 100."
50290 PRINT :PRINT
50295 INPUT "     Please re-enter data,  press  <RETURN>  when ready.", B$
50300 GOTO 50195
```

```
50305 REM
50310 REM
51100 REM ****************** NON-STORED FIXTURE INFO ***************************
51105 REM
51110 REM
51115 CLS
51120 PRINT TAB(30) "LUMINAIRE INFORMATION"
51125 PRINT :PRINT
51130 PRINT "Please enter the following information on the fixture you wish to";
51135 PRINT " use: "
51140 PRINT "(Enter '0' to get help, when shown)
51145 PRINT :PRINT
51150 INPUT "          Fixture Make:                              ", FIXTMAKE$
51155 INPUT "          Fixture Model:                             ", FIXTMODEL$
51160 PRINT
51165 INPUT "          Maintenance Category (OR '0'):             ", MAINCAT$
51175 IF MAINCAT$ = "I" THEN 51220
51180 IF MAINCAT$ = "II" THEN 51220
51185 IF MAINCAT$ = "III" THEN 51220
51190 IF MAINCAT$ = "IV" THEN 51220
51195 IF MAINCAT$ = "V" THEN 51220
51200 IF MAINCAT$ = "VI" THEN 51220
51205 GOSUB 54100
51210 A=1 :GOTO 51295
51215 REM
51220 INPUT "          Distribution Type (OR '0'):                ", DISTTYP
51225 IF DISTTYP < 1 OR DISTTYP > 5 THEN GOSUB 55100 ELSE 51240
51230 A=2 :GOTO 51295
51235 REM
51240 INPUT "          Spacing-to-Mounting Height:                ", STMHRAT
51245 PRINT :PRINT
51250 INPUT "          Lamp Type:                                 ", LTYPE$
51252 INPUT "          Lamp Wattage:                              ", LWATTS
51255 INPUT "          Lamp Quantity:                             ", LQUANT
51260 INPUT "          Initial Lumens:                            ", INITLUM
51265 INPUT "          Maintained Lumens (or '0' for default):    ", MAINTLUM
51270 REM
51275 IF MAINTLUM=0 THEN MAINTLUM = INITLUM*.85
51280 REM
51285 GOTO 51375
51290 REM
51295 CLS
51300 PRINT TAB(30) "LUMINAIRE INFORMATION"
51305 PRINT :PRINT
51310 PRINT "Please enter the following information on the fixture you wish to";
51315 PRINT " use: "
51320 PRINT "(Enter '0' to get help, when shown)
51325 PRINT
51330 PRINT "          Fixture Make:                              "; FIXTMAKE$
51335 PRINT "          Fixture Model:                             "; FIXTMODEL$
51340 PRINT
51345 PRINT "          Maintenance Category (OR '0'):             "; MAINCAT$
51350 IF A=1 THEN 51215
51355 REM
51360 PRINT "          Distribution Type (OR '0'):               "; DISTTYP
51365 GOTO 51240
51370 REM
51375 CLS
51380 PRINT TAB(30) "LUMINAIRE INFORMATION"
51385 PRINT :PRINT
51390 PRINT "     Please verify the following:
51395 PRINT :PRINT
51400 PRINT "          Fixture Make:                 ", " "; FIXTMAKE$
51405 PRINT "          Fixture Model:                ", " "; FIXTMODEL$
51410 PRINT
```

```
51415 PRINT "          Maintenance Category:          ", " "; MAINCAT$
51420 PRINT "          Distribution Type:             ", DISTTYP
51425 PRINT "          Spacing-to-Mounting Height:    ", STMHRAT
51430 PRINT :PRINT
51435 PRINT "          Lamp Type:                     ", " "; LTYPE$
51437 PRINT "          Lamp Wattage:                  ", LWATTS
51440 PRINT "          Lamp Quantity:                 ", LQUANT
51445 PRINT "          Initial Lumens:                ", INITLUM
51450 PRINT "          Maintained Lumens:             ", MAINTLUM
51455 PRINT :PRINT
51460 INPUT "     Is everything correct (Y/N) "; B$
51465 IF B$="N" OR B$="n" THEN 51515
51470 IF LQUANT < 1 THEN 51490
51475 IF INITLUM < MAINTLUM THEN 51500
51480 REM
51485 RETURN
51490 PRINT :PRINT "     Lamp quantity must be greater than one."
51495 GOTO 51515
51500 PRINT :PRINT "     Initial lumens must be greater than maintained lumens."
51505 GOTO 51515
51510 REM
51515 PRINT
51520 INPUT "     Please re-enter data, press <RETURN> when ready. ", B$
51525 GOTO 51115
51530 REM
51535 REM
54100 REM ************** MAINTENANCE CATEGORIES *******************************
54105 REM
54110 REM
54115 CLS
54120 PRINT :PRINT
54125 PRINT TAB(30) "MAINTENANCE CATEGORIES"
54130 PRINT :PRINT :PRINT
54135 PRINT TAB(10) "CHOICE"; TAB(25) "EXAMPLE"; TAB(40) "MAINTENANCE";
54140 PRINT TAB(60) "AMOUNT OF"
54145 PRINT TAB(42) "CATEGORY"; TAB(62) "WORK"
54150 PRINT
54155 FOR A=1 TO 6
54160 PRINT TAB(11) A; TAB(27) (A+6); TAB(45) MCAT$(A,1); TAB(63) MCAT$(A,2)
54165 NEXT A
54170 PRINT :PRINT :PRINT
54175 PRINT "     Enter CHOICE #  for selection or,"
54180 INPUT "          EXAMPLE # for explanation. ", B
54185 IF B < 1 OR B > 12 THEN 54320
54190 IF B < 7 GOTO 54305
54195 REM
54200 CLS
54205 PRINT :PRINT
54210 PRINT TAB(28) "MAINTENANCE CATEGORY EXAMPLE"
54215 PRINT
54220 PRINT TAB(35) "CATEGORY  "; MCAT$(B-6,1)
54225 PRINT :PRINT
54230 PRINT TAB(10) "TOP ENCLOSURE:"
54235 PRINT
54240 FOR A=3 TO 5
54245 PRINT TAB(10) (A-2); ".  "; MCAT$(B-6,A)
54250 NEXT A
54255 PRINT :PRINT
54260 PRINT TAB(10) "BOTTOM ENCLOSURE:"
54265 PRINT
54270 FOR A=6 TO 7
54275 PRINT TAB(10) (A-5); ".  "; MCAT$(B-6,A)
54280 NEXT A
54285 PRINT :PRINT :PRINT :PRINT
54290 INPUT "          Press <RETURN> when ready to continue. ", B$
```

```
54295 GOTO 54115
54300 REM
54305 MAINCAT$ = MCAT$(B,1)
54310 RETURN
54315 REM
54320 PRINT :PRINT
54325 INPUT "     Invalid entry,  press  <RETURN>  to try again.", B$
54330 GOTO 54115
54335 REM
54340 REM
55100 REM ****************** DISTRIBUTION TYPES ********************************
55105 REM
55110 REM
55115 CLS
55120 PRINT :PRINT
55125 PRINT TAB(30) "FIXTURE DISTRIBUTION TYPES"
55130 PRINT :PRINT :PRINT
55135 PRINT TAB(20) "TYPE"; TAB(30) "DISTRIBUTION";
55140 PRINT TAB(51) "% UP"; TAB(61) "% DOWN"
55145 PRINT
55150 FOR A=1 TO 5
55155 PRINT TAB(21) A; TAB(30) DTYPE$(A,1);
55160 PRINT TAB(50) DTYPE$(A,2); TAB(61) DTYPE$(A,3)
55165 NEXT A
55170 PRINT :PRINT :PRINT
55175 PRINT TAB(10) "Enter TYPE # for selection:  ";
55180 INPUT "  ", DISTTYP
55185 IF DISTTYP < 1 OR DISTTYP > 5 THEN 55195
55190 RETURN
55195 PRINT
55200 INPUT "         Invalid entry,  press  <RETURN>  to try again. ", B$
55205 GOTO 55115
55210 REM
55215 REM
57100 REM ****************** HARDCOPY ******************************************
57105 REM
57110 REM
57115 CLS
57120 PRINT :PRINT :PRINT :PRINT :PRINT :PRINT
57125 PRINT TAB(10);
57130 INPUT "Be sure that your Printer is on, press  <RETURN>  to continue.", B$
57135 PRINT :PRINT :PRINT :PRINT TAB(32) "PRINTING"
57140 REM
57145 REM
57150 LPRINT TAB(20) "INTERIOR LIGHTING DESIGN PROGRAM OUTPUT"
57155 LPRINT
57160 LPRINT TAB(10) "BUILDING # "; BLDG$;
57165 LPRINT TAB(34) "ROOM # "; ROOM$;
57170 LPRINT TAB(56) "ITERATION: "; ITERATE
57175 LPRINT :LPRINT
57180 LPRINT TAB(10) "ROOM INFORMATION:"
57185 LPRINT
57190 LPRINT TAB(13) "Use: "; ROOMUSE$;
57195 LPRINT TAB(45) "FC Required: "; FCLEVEL
57200 LPRINT
57205 LPRINT TAB(13) "Length: "; RMLGTH;
57210 LPRINT TAB(45) "Perimeter:   "; RMPER
57215 LPRINT TAB(13) "Width:  "; RMWDTH;
57220 LPRINT TAB(45) "Area:        "; RMFAREA
57225 LPRINT
57230 LPRINT TAB(13) "Ceiling Height: "; FTCHGT;
57235 LPRINT TAB(45) "CCR: "; USING "##.##"; TCAVRAT
57240 LPRINT TAB(13) "Fixture Height: "; FTFHGT;
57245 LPRINT TAB(45) "RCR: "; USING "##.##"; RCAVRAT
57250 LPRINT TAB(13) "Working Height: "; FTWSHGT;
```

```
57255 LPRINT TAB(45) "FCR: "; USING "##.##"; FCAVRAT
57260 LPRINT
57265 LPRINT TAB(13) "C. Color: "; CLCOLOR$;
57270 LPRINT TAB(40) "Reflectance: "; CEILREF;
57275 LPRINT TAB(60) "Effective: "; EFFCREF
57280 LPRINT TAB(13) "W. Color: "; WLCOLOR$;
57285 LPRINT TAB(40) "Reflectance: "; WALLREF
57290 LPRINT TAB(13) "F. Color: "; FLCOLOR$;
57295 LPRINT TAB(40) "Reflectance: "; FLOOREF;
57300 LPRINT TAB(60) "Effective: "; EFFFREF
57305 LPRINT
57310 LPRINT TAB(13) "Room Condition: "; DIRTCD$;
57315 LPRINT TAB(45) "Cleaning Cycle: "; CLCYCLE; " months"
57320 REM
57325 LPRINT :LPRINT
57330 LPRINT TAB(10) "LUMINAIRE INFORMATION: "
57335 LPRINT
57340 LPRINT TAB(13) "Fixture File # "; FIXTFILE$
57345 LPRINT TAB(13) "Fixture Make:  "; FIXTMAKE$;
57350 LPRINT TAB(45) "Lamp File # "; LAMPFILE$
57355 LPRINT TAB(13) "Fixture Model: "; FIXTMODEL$;
57360 LPRINT TAB(45) "Lamp Type:  "; LTYPE$
57365 LPRINT
57370 LPRINT TAB(13) "S/MH Ratio:          "; STMHRAT;
57375 LPRINT TAB(45) "Lamp Quantity:     "; LQUANT
57380 LPRINT TAB(13) "Maintenance Category: "; MAINCAT$;
57385 LPRINT TAB(45) "Initial Lumens:     "; INITLUM
57390 LPRINT TAB(13) "Distribution Type:   "; DISTTYP;
57395 LPRINT TAB(45) "Maintained Lumens: "; MAINTLUM
57400 LPRINT
57405 LPRINT TAB(13) "Necessary Values from"
57410 LPRINT TAB(13) "Fixture's CU Chart: ";
57415 LPRINT TAB(45) "LLD:                 "; USING "#.###"; LLD
57420 LPRINT TAB(45) "LDD:                 "; USING "#.###"; LDD
57425 LPRINT TAB(13) "RFR"; TAB(17) ":"; TAB(19) RFR(2);
57430 LPRINT TAB(45) "RSDD:                "; USING "#.###"; RSDD
57435 LPRINT TAB(13) "RCR"; TAB(17) ":"; TAB(18) RCR(D1);
57440 IF D2 > 0 THEN LPRINT TAB(30) RCR(D2);
57445 LPRINT TAB(45) "Total LLF:           "; USING "#.###"; LLF
57450 LPRINT TAB(13) "PWR"; TAB(17) ":"; TAB(18) PWR(C1);
57455 IF C2 > 0 THEN LPRINT TAB(24) PWR(C2);
57460 IF D2 > 0 THEN LPRINT TAB(30) PWR(C1); ELSE 57470
57465 IF C2 > 0 THEN LPRINT TAB(36) PWR(C2);
57470 LPRINT ""
57475 LPRINT TAB(13) "RCR"; TAB(17) ":";
57480 LPRINT TAB(45) "Floor Cavity Factor: "; USING "#.###"; FCEF
57485 LPRINT TAB(13) "----:--------------------";
57490 LPRINT TAB(45) "Final CU:            "; USING "#.###"; FINALCU
57495 LPRINT TAB(12) ARATIO; TAB(17) ":"; TAB(18) ACU(1);
57500 IF C2 > 0 THEN LPRINT TAB(24) ACU(2);
57505 IF D2 > 0 THEN LPRINT TAB(30) ACU(3); ELSE 57515
57510 IF C2 > 0 THEN LPRINT TAB(36) ACU(4);
57515 IF E1=1 THEN 57545
57520 LPRINT TAB(12) BRATIO; TAB(17) ":"; TAB(18) BCU(1);
57525 IF C2 > 0 THEN LPRINT TAB(24) BCU(2);
57530 IF D2 > 0 THEN LPRINT TAB(30) BCU(3); ELSE 57540
57535 IF C2 > 0 THEN LPRINT TAB(36) BCU(4);
57540 LPRINT ""
57545 LPRINT :LPRINT
57550 LPRINT TAB(10) "RESULTS: ";
57555 LPRINT TAB(45) "Spacing Criteria Effc: "; USING "###.#"; SPCCRIT
57560 LPRINT
57565 LPRINT TAB(13) "Fixture # Required:  "; USING "###.##"; NUMFIX;
57570 LPRINT TAB(45) "Initial FC Level:      "; ACTFCINIT
57575 LPRINT TAB(13) "Fixture # Used:      "; ACTFIXNUM;
```

```
57580 LPRINT TAB(45) "Maintained FC Level:   "; #CTFCMAIN
57585 REM
57590 REM
57595 GOTO 11290
57600 REM
57605 REM
```

```
200 DIM FTMAN$(20) :DIM PTCOLOR$(20) :DIM PTREFL(20)
202 DIM RMUSE$(26) :DIM RMUSELEVEL(26)
204 DIM LCODE$(5,10,2) :DIM LAMPDATA(5,10,3)
206 DIM SOURCE$(5,2)
208 DIM CFR(4) :DIM CCR(5) :DIM CWR(4)
210 DIM FCODE$(5,10,4) :DIM FIXTDATA(5,10,2)
212 DIM CU1(10,4,2) :DIM CU2(10,3,2)
214 DIM CU3(10,4,1) :DIM CU4(10,3,2)
216 DIM DTYPE$(5,3)
218 DIM MCAT$(6,7)
500 REM
502 SOURCE$(1,1)="Incandescent"          :SOURCE$(1,2)="(INC)"
504 SOURCE$(2,1)="Fluorescent"           :SOURCE$(2,2)="(F)"
506 SOURCE$(3,1)="Mercury Vapor"         :SOURCE$(3,2)="(MV)"
508 SOURCE$(4,1)="Metal Halide"          :SOURCE$(4,2)="(MH)"
510 SOURCE$(5,1)="High Pressure Sodium" :SOURCE$(5,2)="(HPS)"
512 REM
514 REM
516 DTYPE$(1,1)="Indirect"          :DTYPE$(1,2)="90-100"  :DTYPE$(1,3)="0-10"
518 DTYPE$(2,1)="Semi-Indirect"     :DTYPE$(2,2)="60-90"   :DTYPE$(2,3)="10-40"
520 DTYPE$(3,1)="Direct-Indirect" :DTYPE$(3,2)="40-60"   :DTYPE$(3,3)="60-40"
522 DTYPE$(4,1)="Semi-Direct"       :DTYPE$(4,2)="10-40"   :DTYPE$(4,3)="60-90"
524 DTYPE$(5,1)="Direct"            :DTYPE$(5,2)="0-10"    :DTYPE$(5,3)="90-100"
526 REM
528 MCAT$(1,1)="I"  :MCAT$(2,1)="II"  :MCAT$(3,1)="III"
530 MCAT$(4,1)="IV" :MCAT$(5,1)="V"   :MCAT$(6,1)="VI"
532 MCAT$(1,2)="Most"  :MCAT$(2,2)=" - "  :MCAT$(3,2)="Some"
534 MCAT$(4,2)="Some"  :MCAT$(5,2)=" - "  :MCAT$(6,2)="Least"
536 REM
538 REM
540 CFR(1)=70  :CFR(2)=50  :CFR(3)=10  :CFR(4)=0
542 CCR(1)=80  :CCR(2)=70  :CCR(3)=30  :CCR(4)=10  :CCR(5)=0
544 CWR(1)=70  :CWR(2)=50  :CWR(3)=30  :CWR(4)=0
546 REM
1000 CLS :PRINT :PRINT :PRINT :PRINT :PRINT :PRINT
1010 PRINT TAB(17) "Please place your DATA DISK in the 'A' drive."
1015 PRINT
1020 PRINT
1025 INPUT "                          Press  RETURN  when ready...", B$
1030 REM
1035 OPEN "I", #1, "A:LAMPDATA.DAT"
1040 FOR A=1 TO 5
1045 FOR B=1 TO 10
1050 INPUT#1, LCODE$(A,B,1), LCODE$(A,B,2)
1055 INPUT#1, LAMPDATA(A,B,1), LAMPDATA(A,B,2), LAMPDATA(A,B,3)
1060 NEXT B
1065 NEXT A
1070 CLOSE #1
1075 REM
1080 OPEN "I", #1, "A:FIXTDATA.DAT"
1085 FOR A=1 TO 5
1090 FOR B=1 TO 10
1095 INPUT#1, FCODE$(A,B,1), FCODE$(A,B,2), FCODE$(A,B,3), FCODE$(A,B,4)
1100 INPUT#1, FIXTDATA(A,B,1), FIXTDATA(A,B,2)
1105 NEXT B
1110 NEXT A
1115 CLOSE #1
1120 REM
1125 REM
1130 OPEN "I", #1, "A:REFLECTR.DAT"
1135 FOR A=1 TO 30
```

```
1140 INPUT#1, PTMAN$(A), PTCOLOR$(A), PTREFL(A)
1145 NEXT A
1150 CLOSE #1
1155 REM
1160 REM
1165 OPEN "I", #1, "A:AFR8815.INF"
1170 FOR A=1 TO 35
1175 INPUT#1, RMUSE$(A), RMUSELEVEL(A)
1180 NEXT A
1185 CLOSE #1
1190 REM
1195 REM
1200 OPEN "I", #1, "A:MAINTCAT.INF"
1205 FOR A=1 TO 6
1210 FOR B=1 TO 7
1215 INPUT#1, MCAT$(A,B)
1220 NEXT B
1225 NEXT A
1230 CLOSE #1
1235 REM
1240 REM
4100 REM ****************** MENU -- C1 ****************************************
4105 REM
4110 REM
4115 CLS
4120 PRINT
4125 PRINT TAB(35) "MENU -- C1"
4130 PRINT :PRINT :PRINT
4135 PRINT TAB(20) "TYPE"; TAB(40) "PROCEDURE"
4140 PRINT :PRINT
4145 PRINT TAB(22) "1"; TAB(40) "Update Menu"
4150 PRINT
4155 PRINT TAB(22) "2"; TAB(40) 'Hardcopy Menu"
4160 PRINT :PRINT
4165 PRINT TAB(22) "3"; TAB(40) "RETURN TO MAIN MENU"
4170 PRINT :PRINT :PRINT
4175 INPUT "               Please enter selected procedure:     ", B
4180 REM
4185 ON B GOTO 5100,6100,4195
4190 GOTO 4100
4195 CLS :PRINT :PRINT :PRINT :PRINT
4200 PRINT TAB(20) "Place your PROGRAM DISK in the 'A' drive."
4205 PRINT :PRINT
4210 PRINT TAB(26); :INPUT "Press <RETURN> when ready. ", B
4215 PRINT :PRINT :PRINT
4220 PRINT TAB(31) "LOADING MENU -- A"
4225 CHAIN "A:LIGHT1A",100
4230 REM
4235 REM
5100 REM ****************** MENU -- C2 ****************************************
5105 REM
5110 CLS :PRINT
5115 PRINT TAB(35) "MENU -- C2"
5120 PRINT TAB(24) "CHANGE / UPDATE INFORMATION DATA"
5125 PRINT :PRINT :PRINT
5130 PRINT ,"TYPE" ,"PROCEDURE"
5135 PRINT
5140 PRINT ,"1","Update AFM 88-15 Information"
5145 PRINT
5150 PRINT ,"2","Update Color Reflectance Data"
5155 PRINT
5160 PRINT ,"3","Update Fixture Data"
5165 PRINT
5170 PRINT ,'4","Update Lamp Data"
5175 PRINT
```

```
5180 PRINT
5185 PRINT ,"5","RETURN TO MENU -- C1"
5190 PRINT :PRINT :PRINT :PRINT
5195 INPUT "                    Please enter selected procedure. ", B
5200 REM
5205 ON B GOSUB 29100,30100,32100,34100,5215
5210 GOTO 5100
5215 GOTO 4100
5220 REM
5225 REM
6100 REM ****************** MENU -- C3 (HARDCOPY) ******************************
6105 REM
6110 REM
6115 CLS
6120 PRINT
6125 PRINT TAB(35) "MENU -- C3"
6130 PRINT TAB(36) "HARDCOPY"
6135 PRINT :PRINT :PRINT
6140 PRINT TAB(20) "TYPE"; TAB(40) "PROCEDURE"
6145 PRINT :PRINT
6150 PRINT TAB(22) "1"; TAB(40) "AFR 88-15 FC Levels"
6155 PRINT
6160 PRINT TAB(22) "2"; TAB(40) "Color Chart"
6165 PRINT
6170 PRINT TAB(22) "3"; TAB(40) "Fixture Choices"
6175 PRINT
6180 PRINT TAB(22) "4"; TAB(40) "Lamp Choices"
6185 PRINT
6190 PRINT TAB(22) "5"; TAB(40) "Specific CU Tables"
6195 PRINT :PRINT
6200 PRINT TAB(22) "6"; TAB(40) "RETURN TO MENU -- C1"
6205 PRINT :PRINT
6210 INPUT "                Please enter selected procedure. ", B
6215 REM
6220 ON B GOSUB 54100,55100,57100,58100,60100,6230
6225 GOTO 6100
6230 GOTO 4100
6235 REM
6240 REM
29100 REM ****************** UPDATE AFR 88-15 FC LEVELS ************************
29105 REM
29110 REM
29115 CLS :PRINT :PRINT :PRINT :PRINT
29120 PRINT TAB(27) "UPDATA AFR 88-15 FC LEVELS"
29125 PRINT :PRINT
29130 PRINT TAB(15) "This procedure allows you to change the AFR 88-15"
29135 PRINT TAB(15) "FC levels currently in memory and on disk."
29140 PRINT :PRINT
29145 PRINT TAB(15) "Enter (1) to continue, or"
29150 PRINT TAB(15) "      (2) to return to menu"
29155 INPUT "                    "; B
29160 IF B=2 THEN RETURN
29165 B=1 :D=0
29170 CLS
29175 PRINT TAB(15) "ROOM TYPE"; TAB(30) "ROOM USE"; TAB(60) "FC LEVEL"
29180 PRINT
29185 FOR A=B TO (B+11)
29190 PRINT TAB(18) A; TAB(30) RMUSE$(A); TAB(63) RMUSELEVEL(A)
29195 NEXT A
29200 PRINT
29205 PRINT TAB(18) (B+12); TAB(30) "OTHER"
29210 PRINT :PRINT :PRINT TAB(15)
29215 INPUT "To change information, enter TYPE # or (0) to quit. ", RMTYPE
29220 IF RMTYPE = 0 THEN 29345
29225 IF RMTYPE < (B+1) AND RMTYPE > (B+12) THEN 29200
```

```
29220 IF RMTYPE > 37 THEN 29335
29225 IF D=1 OR D=2 THEN 29245
29240 B=10 :D=1 :GOTO 29170
29245 IF D=2 THEN 29255
29250 B=25 :D=2 :GOTO 29170
29255 B=1 :D=0 :GOTO 29170
29260 CLS
29265 PRINT :PRINT :PRINT
29270 PRINT TAB(15) "Please enter the following information: ";
29275 PRINT "for Room Type #"; RMTYPE
29280 PRINT :PRINT :PRINT TAB(25);
29285 INPUT "Room Use:              "; RMUSE$(RMTYPE)
29290 PRINT
29295 PRINT TAB(25);
29300 INPUT "FC Level Required:     "; RMUSELEVEL(RMTYPE)
29305 PRINT :PRINT :PRINT
29310 INPUT "              Is Everything Correct (Y/N) "; B$
29315 IF B$="N" OR B$="n" THEN 29325
29320 GOTO 29165
29325 PRINT :PRINT :PRINT TAB(12)
29330 INPUT "Please enter correct information, press <RETURN> when ready.", B$
29335 GOTO 29260
29340 REM
29345 CLS
29350 PRINT :PRINT :PRINT :PRINT :PRINT
29355 PRINT TAB(30) "SAVING NEW INFORMATION"
29360 OPEN "O", #1, "A:AFR8815.INF"
29365 FOR A=1 TO 36
29370 WRITE#1, RMUSE$(A), RMUSELEVEL(A)
29375 NEXT A
29380 CLOSE #1
29385 REM
29390 RETURN
29395 CLS
29400 PRINT :PRINT :PRINT :PRINT
29405 INPUT "          Invalid entry, press <RETURN> to try again. ", B$
29410 GOTO 29170
29415 REM
29420 REM
30100 REM ****************** UPDATE COLOR CHART ********************************
30105 REM
30110 REM
30115 CLS :PRINT :PRINT :PRINT :PRINT
30120 PRINT TAB(31) "UPDATE COLOR CHART"
30125 PRINT :PRINT
30130 PRINT TAB 17) "This procedure allows you to change the color"
30135 PRINT TAB(17) "chart currently in memory and on disk."
30140 PRINT :PRINT
30145 PRINT TAB(17) "Enter (1) to continue, or"
30150 PRINT TAB(17) "      (2) to return to menu."
30155 INPUT "                    "; B
30160 IF B=2 THEN RETURN
30165 B=1
30170 CLS
30175 PRINT
30180 PRINT ,"TYPE #", "BRAND", "COLOR", "REFLECTIVITY"
30185 PRINT
30190 FOR A=B TO (B+14)
30195 PRINT ,A, PTMAN$(A), PTCOLOR$(A); TAB(60) PTREFL(A)
30200 NEXT A
30205 PRINT :PRINT ,(B+15), "OTHER"
30210 PRINT
30215 INPUT "     To correct data, enter TYPE # or (0) to quit. ", REFTYPE
30220 IF REFTYPE=0 THEN 30345
30225 IF REFTYPE < (B-1) AND REFTYPE > (B+15) THEN 30250
```

```
30220 IF REFTYPE > 31 THEN 30390
30225 IF B=16 THEN B=1 ELSE 30245
30240 GOTO 30170
30245 B=B+15 : GOTO 30170
30250 REM
30255 CLS :PRINT :PRINT
30260 PRINT TAB(19) "Enter the following information to replace"
30265 PRINT TAB(19) "the reflectance data for TYPE # "; REFTYPE
30270 PRINT :PRINT
30275 INPUT "               Paint Manufacturer:       "; PMAN$
30280 PTMAN$(REFTYPE)=PMAN$ :PRINT
30285 INPUT "               Paint Color:              "; PCOLOR$
30290 PTCOLOR$(REFTYPE)=PCOLOR$ :PRINT
30295 INPUT "               Reflectance (no decimal): "; PREFL
30300 PTREFL(REFTYPE)=PREFL
30305 PRINT :PRINT :PRINT
30310 INPUT "               Is everything correct (Y/N) "; B$
30315 IF B$="N" OR B$="n" THEN 30325
30320 GOTO 30165
30325 PRINT :PRINT :PRINT :PRINT TAB(10);
30330 INPUT "Please enter correct information, press <RETURN> when ready.", B$
30335 GOTO 30255
30340 REM
30345 CLS :PRINT :PRINT :PRINT :PRINT :PRINT
30350 PRINT TAB(28) "SAVING NEW INFORMATION"
30355 REM
30360 OPEN "O", #1, "A:REFLECTR.DAT"
30365 FOR A=1 TO 30
30370 WRITE#1, PTMAN$(A), PTCOLOR$(A), PTREFL(A)
30375 NEXT A
30380 CLOSE #1
30385 RETURN
30390 PRINT :PRINT
30395 INPUT "     Invalid entry, press <RETURN> to try again. ", B$
30400 GOTO 30165
30405 REM
30410 REM
32100 REM ****************** UPDATE FIXTURE FILES ****************************
32105 REM
32110 REM
32115 CLS :PRINT :PRINT :PRINT :PRINT
32120 PRINT TAB(30) "UPDATE FIXTURE FILES"
32125 PRINT :PRINT
32130 PRINT TAB(16) "This procedure allows you to change the fixture"
32135 PRINT TAB(16) "data currently in memory and on disk."
32140 PRINT :PRINT
32145 PRINT TAB(16) "Enter (1) to continue, or"
32150 PRINT TAB(16) "      (2) to return to menu."
32155 INPUT "                  "; B
32160 IF B=2 THEN RETURN
32165 CLS
32170 PRINT :PRINT
32175 PRINT TAB(30) "UPDATE FIXTURE FILES"
32180 PRINT :PRINT :PRINT
32185 PRINT TAB(20) "CHOICE"; TAB(40) "FIXTURE TYPE"
32190 PRINT :PRINT
32195 FOR A=1 TO 5
32200 PRINT TAB(22) A; TAB(40) SOURCE$(A,1); TAB(62) SOURCE$(A,2)
32205 NEXT A
32210 PRINT :PRINT
32215 PRINT
32220 PRINT TAB(22) A; TAB(40) "RETURN TO MENU -- 0"
32225 PRINT :PRINT :PRINT
32230 INPUT "               Enter CHOICE # for fixture selection: ", FT
32235 IF FT < 1 OR FT > 6 GOTO 32060
```

```
32240 REM
32245 IF FT = 5 THEN 32680
32250 REM
32255 REM
32260 CLS
32265 PRINT TAB(21) "UPDATE FIXTURE FILES:  "; SOURCE$(FT,1); " Fixtures"
32270 PRINT :PRINT
32275 PRINT "CHOICE"; TAB(12) "FILE #"; TAB(22) "MAKE"; TAB(37) "MODEL #";
32280 PRINT TAB(51) "MAINT."; TAB(64) "DIST."; TAB(74) "S/MH"
32285 PRINT TAB(50) "CATEGORY"; TAB(64) "TYPE"
32290 PRINT
32295 FOR A=1 TO 10
32300 PRINT TAB(3) A; TAB(12) FCODE$(FT,A,1); TAB(22) FCODE$(FT,A,2);
32305 PRINT TAB(37) FCODE$(FT,A,3); TAB(53) FCODE$(FT,A,4);
32310 PRINT TAB(65) FIXTDATA(FT,A,2); TAB(74) FIXTDATA(FT,A,1)
32315 NEXT A
32320 PRINT :PRINT
32325 INPUT "     To change fixture data, enter CHOICE # or (0) to quit: ", FC
32330 IF FC = 0 GOTO 32685
32335 IF FC < 0 OR FC > 10 GOTO 32600
32340 REM
32345 REM
32350 CLS
32355 PRINT :PRINT
32360 PRINT TAB(20) "UPDATE FIXTURE FILES:  "; SOURCE$(FT,1); " Fixtures"
32365 PRINT :PRINT :PRINT
32370 PRINT "     Enter the following data:"
32375 PRINT :PRINT :PRINT
32380 INPUT "                Fixture Make:          "; FCODE$(FT,FC,2)
32385 PRINT
32390 INPUT "                Fixture Model:         "; FCODE$(FT,FC,3)
32395 PRINT
32400 INPUT "                Fixture's S/MH Ratio:  "; FIXTDATA(FT,FC,1
32410 GOSUB 32170
32415 GOSUB 32180
32420 REM
32425 CLS
32430 PRINT :PRINT
32470 PRINT TAB(20) "Update Fixture Files:  "; SOURCE$(FT,1); " Fixtures"
32475 PRINT :PRINT
32440 PRINT TAB(10) "You have chosen:"
32445 PRINT
32450 PRINT TAB(20) "Fixture Make:"; TAB(55) FCODE$(FT,FC,2)
32455 PRINT
32460 PRINT TAB(20) "Fixture Model:"; TAB(55) FCODE$(FT,FC,3)
32465 PRINT
32470 PRINT TAB(20) "Fixture's Maintenance Category:"; TAB(55) FCODE$(FT,FC,4)
32475 PRINT
32480 PRINT TAB(20) "Fixture's Distribution Type:"; TAB(55) FIXTDATA(FT,FC,2)
32485 PRINT
32490 PRINT TAB(20) "Fixture's S/MH Ratio: "; TAB(55) FIXTDATA(FT,FC,1)
32495 PRINT :PRINT
32500 INPUT "     Is everything correct (Y/N) "; B$
32505 IF B$="N" OR B$="n" GOTO 32555
32510 PRINT
32515 PRINT
32520 INPUT "     Now enter CU chart values, press <RETURN> when ready. ", B$
32525 IF FT=1 THEN GOSUB 36100
32530 IF FT=2 THEN GOSUB 36100
32535 IF FT=3 THEN GOSUB 37100
32540 IF FT=4 THEN GOSUB 37100
32545 IF FT=5 THEN GOSUB 37100
32550 GOTO 32580
32555 PRINT
32560 INPUT       Please re-enter data, press <RETURN> when ready. ", B$
```

```
32565 GOTO 32350
32570 REM
32575 REM
32580 CLS
32585 PRINT :PRINT :PRINT :PRINT :PRINT :PRINT
32590 PRINT TAB(34) "SAVING DATA"
32595 REM
32600 IF FT=1 THEN 32625
32605 IF FT=2 THEN 32680
32610 IF FT=3 THEN 32820
32615 IF FT=4 THEN 32875
32620 IF FT=5 THEN 32930
32625 IF FC=1 THEN OPEN "O", #1, "A:INCU1.DAT"
32630 IF FC=2 THEN OPEN "O", #1, "A:INCU2.DAT"
32635 IF FC=3 THEN OPEN "O", #1, "A:INCU3.DAT"
32640 IF FC=4 THEN OPEN "O", #1, "A:INCU4.DAT"
32645 IF FC=5 THEN OPEN "O", #1, "A:INCU5.DAT"
32650 IF FC=6 THEN OPEN "O", #1, "A:INCU6.DAT"
32655 IF FC=7 THEN OPEN "O", #1, "A:INCU7.DAT"
32660 IF FC=8 THEN OPEN "O", #1, "A:INCU8.DAT"
32665 IF FC=9 THEN OPEN "O", #1, "A:INCU9.DAT"
32670 IF FC=10 THEN OPEN "O", #1, "A:INCU10.DAT"
32675 GOTO 32735
32680 IF FC=1 THEN OPEN "O", #1, "A:FLCU1.DAT"
32685 IF FC=2 THEN OPEN "O", #1, "A:FLCU2.DAT"
32690 IF FC=3 THEN OPEN "O", #1, "A:FLCU3.DAT"
32695 IF FC=4 THEN OPEN "O", #1, "A:FLCU4.DAT"
32700 IF FC=5 THEN OPEN "O", #1, "A:FLCU5.DAT"
32705 IF FC=6 THEN OPEN "O", #1, "A:FLCU6.DAT"
32710 IF FC=7 THEN OPEN "O", #1, "A:FLCU7.DAT"
32715 IF FC=8 THEN OPEN "O", #1, "A:FLCU8.DAT"
32720 IF FC=9 THEN OPEN "O", #1, "A:FLCU9.DAT"
32725 IF FC=10 THEN OPEN "O", #1, "A:FLCU10.DAT"
32730 REM
32735 FOR D=1 TO 2
32740 FOR C=1 TO 3
32745 FOR B=1 TO 10
32750 WRITE#1, CU1(B,C,D)
32755 NEXT B
32760 NEXT C
32765 NEXT D
32770 FOR D=1 TO 2
32775 FOR C=1 TO 3
32780 FOR B=1 TO 10
32785 WRITE#1, CU2(B,C,D)
32790 NEXT B
32795 NEXT C
32800 NEXT D
32805 CLOSE #1
32810 GOTO 32165
32815 REM
32820 IF FC=1 THEN OPEN "O", #1, "A:MVCU1.DAT"
32825 IF FC=2 THEN OPEN "O", #1, "A:MVCU2.DAT"
32830 IF FC=3 THEN OPEN "O", #1, "A:MVCU3.DAT"
32835 IF FC=4 THEN OPEN "O", #1, "A:MVCU4.DAT"
32840 IF FC=5 THEN OPEN "O", #1, "A:MVCU5.DAT"
32845 IF FC=6 THEN OPEN "O", #1, "A:MVCU6.DAT"
32850 IF FC=7 THEN OPEN "O", #1, "A:MVCU7.DAT"
32855 IF FC=8 THEN OPEN "O", #1, "A:MVCU8.DAT"
32860 IF FC=9 THEN OPEN "O", #1, "A:MVCU9.DAT"
32865 IF FC=10 THEN OPEN "O", #1, "A:MVCU10.DAT"
32870 GOTO 32985
32875 IF FC=1 THEN OPEN "O", #1, "A:MHCU1.DAT"
32880 IF FC=2 THEN OPEN "O", #1, "A:MHCU2.DAT"
32885 IF FC=3 THEN OPEN "O", #1, "A:MHCU3.DAT"
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32890 IF FC=4 THEN OPEN "O", #1, "A:MHCU4.DAT"
32895 IF FC=5 THEN OPEN "O", #1, "A:MHCU5.DAT"
32900 IF FC=6 THEN OPEN "O", #1, "A:MHCU6.DAT"
32905 IF FC=7 THEN OPEN "O", #1, "A:MHCU7.DAT"
32910 IF FC=8 THEN OPEN "O", #1, "A:MHCU8.DAT"
32915 IF FC=9 THEN OPEN "O", #1, "A:MHCU9.DAT"
32920 IF FC=10 THEN OPEN "O", #1, "A:MHCU10.DAT"
32925 GOTO 32985
32930 IF FC=1 THEN OPEN "O", #1, "A:HPCU1.DAT"
32935 IF FC=2 THEN OPEN "O", #1, "A:HPCU2.DAT"
32940 IF FC=3 THEN OPEN "O", #1, "A:HPCU3.DAT"
32945 IF FC=4 THEN OPEN "O", #1, "A:HPCU4.DAT"
32950 IF FC=5 THEN OPEN "O", #1, "A:HPCU5.DAT"
32955 IF FC=6 THEN OPEN "O", #1, "A:HPCU6.DAT"
32960 IF FC=7 THEN OPEN "O", #1, "A:HPCU7.DAT"
32965 IF FC=8 THEN OPEN "O", #1, "A:HPCU8.DAT"
32970 IF FC=9 THEN OPEN "O", #1, "A:HPCU9.DAT"
32975 IF FC=10 THEN OPEN "O", #1, "A:HPCU10.DAT"
32980 REM
32985 FOR C=1 TO 4
32990 FOR B=1 TO 10
32995 WRITE#1, CU3(B,C,1)
33000 NEXT B
33005 NEXT C
33010 FOR D=1 TO 2
33015 FOR C=1 TO 3
33020 FOR B=1 TO 10
33025 WRITE#1, CU4(B,C,D)
33030 NEXT B
33035 NEXT C
33040 NEXT D
33045 REM
33050 CLOSE #1
33055 GOTO 32260
33060 PRINT :PRINT
33065 INPUT "     Invalid entry, press  RETURN  to try again. "; E$
33070 GOTO 32165
33075 REM
33080 OPEN "O", #1, "A:FIXTDATA.DAT"
33085 FOR A=1 TO 5
33090 FOR B=1 TO 10
33095 WRITE#1, FCODE$(A,B,1), FCODE$(A,B,2), FCODE$(A,B,3), FCODE$(A,B,4)
33100 WRITE#1, FIXTDATA(A,B,1), FIXTDATA(A,B,2)
33105 NEXT B
33110 NEXT A
33115 CLOSE #1
33120 REM
33125 RETURN
33130 REM
33135 REM
34100 REM ****************** UPDATE LAMP FILES ********************************
34105 REM
34110 REM
34115 CLS :PRINT :PRINT :PRINT :PRINT
34120 PRINT TAB(31) "UPDATE LAMP FILES"
34125 PRINT :PRINT
34130 PRINT TAB(18) "This procedure allows you to change the lamp"
34135 PRINT TAB(18) "data currently in memory and on disk."
34140 PRINT :PRINT
34145 PRINT TAB(18) "Enter (1) to continue, or"
34150 PRINT TAB(18) "      (2) to return to menu."
34155 INPUT "                        "; B
34160 IF B=2 THEN RETURN
34165 CLS
34170 PRINT :PRINT
```

```
34175 PRINT TAB(32) "UPDATE LAMP FILES"
34180 PRINT :PRINT :PRINT
34185 PRINT TAB(20) "CHOICE"; TAB(40) "LAMP TYPE"
34190 PRINT :PRINT
34195 FOR A=1 TO 5
34200 PRINT TAB(22) A; TAB(40) SOURCE$(A,1); TAB(62) SOURCE$(A,2)
34205 NEXT A
34210 PRINT :PRINT
34215 PRINT TAB(22) A; TAB(40) "STORE DATA CHANGES"
34220 PRINT
34225 PRINT TAB(22) A+1; TAB(40) "RETURN TO MENU -- C2"
34230 PRINT :PRINT :PRINT
34235 INPUT "                Enter CHOICE # for lamp selection: ", LT
34240 IF LT < 1 OR LT > 7 GOTO 34520
34245 IF LT = 6 GOTO 34460
34250 IF LT = 7 THEN RETURN
34255 REM
34260 REM
34265 CLS
34270 PRINT TAB(21) "UPDATE LAMP FILES:  "; SOURCE$(LT,1); " Lamps"
34275 PRINT :PRINT
34280 PRINT TAB(8) "CHOICE"; TAB(19) "FILE #"; TAB(31) "CODE";
34285 PRINT TAB(43) "WATTS"; TAB(55) "INITIAL"; TAB(68) "MAINT."
34290 PRINT TAB(55) "LUMENS"; TAB(68) "LUMENS"
34295 PRINT
34300 FOR A=1 TO 10
34305 PRINT TAB(10) A; TAB(19) LCODE$(LT,A,1); TAB(30) LCODE$(LT,A,2);
34310 PRINT TAB(43) LAMPDATA(LT,A,1); TAB(55) LAMPDATA(LT,A,2);
34315 PRINT TAB(68) LAMPDATA(LT,A,3)
34320 NEXT A
34325 PRINT :PRINT
34330 INPUT "     To change lamp data, enter CHOICE # or (0) to quit: ", LC
34335 IF LC = 0 GOTO 34165
34340 IF LC < 0 OR LC > 10 GOTO 34520
34345 REM
34350 REM
34355 CLS
34360 PRINT :PRINT
34365 PRINT TAB(21) "Update Lamp Files:  "; SOURCE$(LT,1); " Lamps"
34370 PRINT :PRINT
34375 INPUT "          Enter Lamp Code:                "; LCODE$(LT,LC,2)
34380 PRINT
34385 INPUT "          Enter Lamp Watts:               "; LAMPDATA(LT,LC,1)
34390 PRINT
34395 INPUT "          Enter Lamp's Initial Lumens:    "; LAMPDATA(LT,LC,2)
34400 PRINT
34405 INPUT "          Enter Lamp's Maintained Lumens: "; LAMPDATA(LT,LC,3)
34410 PRINT :PRINT
34415 INPUT "     Is everything correct (Y/N) "; B$
34420 IF B$="N" OR B$="n" GOTO 34435
34425 IF LAMPDATA(LT,LC,2) < LAMPDATA(LT,LC,3) THEN 34535
34430 GOTO 34265
34435 PRINT
34440 INPUT "     Please re-enter data, press <RETURN> when ready. ", B$
34445 GOTO 34355
34450 REM
34455 REM
34460 CLS
34465 PRINT :PRINT :PRINT :PRINT :PRINT
34470 PRINT TAB(34) "SAVING DATA"
34475 OPEN "O", #1, "A:LAMPDATA.DAT"
34480 FOR A=1 TO 5
34485 FOR B=1 TO 10
34490 WRITE#1, LCODE$(A,B,1), LCODE$(A,B,2)
34495 WRITE#1, LAMPDATA(A,B,1), LAMPDATA(A,B,2), LAMPDATA(A,B,3)
```

```
34500 NEXT B
34505 NEXT A
34510 CLOSE #1
34515 GOTO 34165
34520 PRINT :PRINT
34525 INPUT "     Invalid entry, press <RETURN> to try again. ", B$
34530 GOTO 34165
34535 PRINT :PRINT
34540 PRINT "     Initial lumens must be greater than maintained lumens."
34545 PRINT
34550 INPUT "     Please re-enter data, press <RETURN> when ready. ", B$
34555 GOTO 34355
34560 REM
34565 REM
36100 REM ****************** CU CHART INPUT ************************************
36105 REM           FOR INCANDESCENT AND FLUORESCENT FIXTURES
36110 REM
36115 REM
36120 CLS
36125 PRINT :PRINT :PRINT :PRINT :PRINT
36130 PRINT TAB(8);
36135 PRINT "You will be given reflectance values for the floor, the ceiling,"
36140 PRINT TAB(8);
36145 PRINT "and the wall.  Enter the appropriate CU value that corresponds"
36150 PRINT TAB(8);
36155 PRINT "to these values and to the RCR value that is shown (no decimal)."
36156 PRINT TAB(8);
36157 PRINT "If the CU value is not known, either enter '0' or do manual'
36158 PRINT TAB(8);
36159 PRINT "extrapolation and enter value."
36160 PRINT :PRINT
36165 INPUT "                          Press  <RETURN>  when ready. ', B$
36170 REM
36175 FOR C=1 TO 2
36180 FOR B=1 TO 4
36185 CLS
36190 PRINT TAB(25) "Floor   Reflectance  =  "; CFR(2); "%"
36195 PRINT TAB(25) "Ceiling Reflectance  =  "; CCR(C); "%"
36200 PRINT TAB(25) "Wall    Reflectance  =  "; CWR(B); "%"
36205 PRINT :PRINT :PRINT
36210 PRINT TAB(20) "For RCR of: "; TAB(40) "Enter CU value:"
36215 PRINT
36220 FOR A = 1 TO 10
36225 PRINT TAB(24) A; TAB(46) "";
36230 INPUT CU1(A,B,C)
36235 NEXT A
36240 PRINT :PRINT
36245 INPUT "     Is everything OK so far (Y/N) "; B$
36250 IF B$="N" OR B$="n" THEN 36600
36255 NEXT B
36260 NEXT C
36265 REM
36270 FOR C=1 TO 2
36275 FOR B=1 TO 3
36280 CLS
36285 PRINT TAB(25) "Floor   Reflectance  =  "; CFR(2); "%"
36290 PRINT TAB(25) "Ceiling Reflectance  =  "; CCR(C+2); "%"
36295 PRINT TAB(25) "Wall    Reflectance  =  "; CWR(B+1); "%"
36300 PRINT :PRINT :PRINT
36305 PRINT TAB(20) "For RCR of: "; TAB(40) "Enter CU value:"
36310 PRINT
36315 FOR A = 1 TO 10
36320 PRINT TAB(24) A; TAB(46) "";
36325 INPUT CU2(A,B,C)
36330 NEXT A
```

```
36335 PRINT :PRINT
36340 INPUT "     Is everything OK so far (Y/N) "; B$
36345 IF B$="N" OR B$="n" THEN 36620
36350 NEXT B
36355 NEXT C
36360 REM
36365 CLS
36370 PRINT TAB(15);
36375 PRINT "Here is your CU chart for Fixture File #  "; FCODE$(FT,FC,1)
36380 PRINT
36385 PRINT "FIXTURE MAKE:  "; FCODE$(FT,FC,2);
36390 PRINT TAB(45) "FIXTURE MODEL:  "; FCODE$(FT,FC,3)
36395 PRINT :PRINT
36400 PRINT TAB(5) "CFR"; TAB(46) CFR(2)
36405 PRINT TAB(5) "CCR"; TAB(18) CCR(1); TAB(37) CCR(2);
36410 PRINT TAB(54) CCR(3); TAB(69) CCR(4)
36415 REM
36420 PRINT TAB(5) "CWR";
36425 PRINT TAB(12) CWR(1); CWR(2); CWR(3); CWR(4);
36430 PRINT TAB(31) CWR(1); CWR(2); CWR(3); CWR(4);
36435 PRINT TAB(50) CWR(2); CWR(3); CWR(4);
36440 PRINT TAB(65) CWR(2); CWR(4); CWR(4)
36445 PRINT
36450 REM
36455 PRINT TAB(5) "RCR"
36460 REM
36465 FOR A=1 TO 10
36470 PRINT TAB(5) A;
36475 PRINT TAB(12) "";
36480 FOR B=1 TO 4
36485 PRINT CU1(A,B,1);
36490 NEXT B
36495 PRINT TAB(31) "";
36500 FOR B=1 TO 4
36505 PRINT CU1(A,B,2);
36510 NEXT B
36515 PRINT TAB(50) "";
36520 FOR B=1 TO 3
36525 PRINT CU2(A,B,1);
36530 NEXT B
36535 PRINT TAB(65) "";
36540 FOR B=1 TO 2
36545 PRINT CU2(A,B,2);
36550 NEXT B
36555 PRINT CU2(A,3,2)
36560 NEXT A
36565 PRINT
36570 INPUT "Is everything correct (Y/N) "; B$
36575 IF B$="N" OR B$="n" THEN 36585
36580 RETURN
36585 PRINT "Please re-enter all CU data for this fixture,  ";
36590 INPUT "press <RETURN> when ready. ", B$
36595 GOTO 36120
36600 REM
36605 PRINT
36610 INPUT "     Please re-enter data, press <RETURN> when ready. ", B$
36615 GOTO 36185
36620 REM
36625 PRINT
36630 INPUT "     Please re-enter data, press <RETURN> when ready. ", B$
36635 GOTO 36280
37100 REM ****************** CU CHART INPUT ************************************
37105 REM           FOR MERCURY VAPOR, METAL HALIDE & HPS FIXTURES
37110 REM
37115 REM
```

```
37120 CLS
37125 PRINT :PRINT :PRINT :PRINT :PRINT
37130 PRINT TAB(8);
37135 PRINT "You will be given reflectance values for the floor, the ceiling,"
37140 PRINT TAB(8);
37145 PRINT "and the wall.  Enter the appropriate CU value that corresponds"
37150 PRINT TAB(8);
37155 PRINT "to these values and to the RCR value that is shown (no decimal)."
37156 PRINT TAB(8);
37157 PRINT "If the CU value is not known, either enter '0' or do manual"
37158 PRINT TAB(8);
37159 PRINT "extrapolation and enter value."
37160 PRINT :PRINT
37165 INPUT "                          Press  <RETURN>  when ready. ", B$
37170 REM
37175 FOR B=1 TO 4
37180 CLS
37185 PRINT TAB(25) "Floor   Reflectance  =  "; CFR(2); "%"
37190 PRINT TAB(25) "Ceiling Reflectance  =  "; CCR(1); "%"
37195 PRINT TAB(25) "Wall    Reflectance  =  "; CWR(B); "%"
37200 PRINT :PRINT :PRINT
37205 PRINT TAB(20) "For RCR of: "; TAB(40) "Enter CU value:"
37210 PRINT
37215 FOR A = 1 TO 10
37220 PRINT TAB(24) A; TAB(46) "";
37225 INPUT CU3(A,B,1)
37230 NEXT A
37235 PRINT :PRINT
37240 INPUT "     Is everything OK so far (Y/N) "; B$
37245 IF B$="N" OR B$="n" THEN 37575
37250 NEXT B
37255 REM
37260 D=2
37265 FOR C=1 TO 2
37270 FOR B=1 TO 3
37275 CLS
37280 PRINT TAB(25) "Floor   Reflectance  =  "; CFR(2); "%"
37285 PRINT TAB(25) "Ceiling Reflectance  =  "; CCR(C+D); "%"
37290 PRINT TAB(25) "Wall    Reflectance  =  "; CWR(B+1); "%"
37295 PRINT :PRINT :PRINT
37300 PRINT TAB(20) "For RCR of: "; TAB(40) "Enter CU value:"
37305 PRINT
37310 FOR A = 1 TO 10
37315 PRINT TAB(24) A; TAB(46) "";
37320 INPUT CU4(A,B,C)
37325 NEXT A
37330 PRINT :PRINT
37335 INPUT "     Is everything OK so far (Y/N) "; B$
37340 IF B$="N" OR B$="n" THEN 37595
37345 NEXT B
37350 D=3
37355 NEXT C
37360 REM
37365 CLS
37370 PRINT TAB(15);
37375 PRINT "Here is your CU chart for Fixture File #  "; FCODE$(FT,FC,1)
37380 PRINT
37385 PRINT "FIXTURE MAKE:  "; FCODE$(FT,FC,2);
37390 PRINT TAB(45) "FIXTURE MODEL:  "; FCODE$(FT,FC,3)
37395 PRINT :PRINT
37400 PRINT TAB(10) "CFR"; TAB(26) CFR(2)
37405 PRINT TAB(10) "CCR"; TAB(26) CCR(1); TAB(44) CCR(3);
37410 PRINT TAB(60) CCR(5)
37415 REM
37420 PRINT TAB(10) "CWR";
```

```
37425 PRINT TAB(20) CWR(1); CWR(2); CWR(3); CWR(4);
37430 PRINT TAB(40) CWR(2); CWR(3); CWR(4);
37435 PRINT TAB(56) CWR(2); CWR(4); CWR(4)
37440 PRINT
37445 REM
37450 PRINT TAB(10) "RCR"
37455 REM
37460 FOR A=1 TO 10
37465 PRINT TAB(10) A;
37470 PRINT TAB(20) "";
37475 FOR B=1 TO 4
37480 PRINT CU3(A,B,1);
37485 NEXT B
37490 PRINT TAB(40) "";
37495 FOR B=1 TO 3
37500 PRINT CU4(A,B,1);
37505 NEXT B
37510 PRINT TAB(56) "";
37515 FOR B=1 TO 2
37520 PRINT CU4(A,B,2);
37525 NEXT B
37530 PRINT CU4(A,3,2)
37535 NEXT A
37540 PRINT
37545 INPUT "Is everything correct (Y/N) "; B$
37550 IF B$="N" OR B$="n" THEN 37560
37555 RETURN
37560 PRINT "Please re-enter all CU data for this fixture.  ";
37565 INPUT "press <RETURN> when ready. ", B$
37570 GOTO 37120
37575 REM
37580 PRINT
37585 INPUT "     Please re-enter data, press <RETURN> when ready. ", B$
37590 GOTO 37180
37595 REM
37600 PRINT
37605 INPUT "     Please re-enter data, press <RETURN> when ready. ", B$
37610 GOTO 37275
50100 REM ************** MAINTENANCE CATEGORIES *********************************
50105 REM
50110 REM
50115 CLS
50120 PRINT :PRINT
50125 PRINT TAB(30) "MAINTENANCE CATEGORIES"
50130 PRINT :PRINT :PRINT
50135 PRINT TAB(10) "CHOICE"; TAB(25) "EXAMPLE"; TAB(40) "MAINTENANCE";
50140 PRINT TAB(60) "AMOUNT OF"
50145 PRINT TAB(42) "CATEGORY"; TAB(63) "WORK"
50150 PRINT
50155 FOR A=1 TO 6
50160 PRINT TAB(11) A; TAB(27) (A+6); TAB(45) MCAT$(A,1); TAB(63) MCAT$(A,2)
50165 NEXT A
50170 PRINT :PRINT :PRINT
50175 PRINT "     Enter CHOICE #  for selection, or"
50180 INPUT "          EXAMPLE # for explaination: ", B
50185 IF B < 1 OR B > 12 THEN 50320
50190 IF B < 7 GOTO 50305
50195 REM
50200 CLS
50205 PRINT :PRINT
50210 PRINT TAB(23) "MAINTENANCE CATEGORY EXAMPLE"
50215 PRINT
50220 PRINT TAB(35) "CATEGORY  "; MCAT$(B-6,1)
50225 PRINT :PRINT
50230 PRINT TAB(10) "TOP ENCLOSURE:"
```

```
50235 PRINT
50240 FOR A=3 TO 5
50245 PRINT TAB(10) (A-2); ".  "; MCAT$(B-5,A)
50250 NEXT A
50255 PRINT :PRINT
50260 PRINT TAB(10) "BOTTOM ENCLOSURE:"
50265 PRINT
50270 FOR A=6 TO 7
50275 PRINT TAB(10) (A-5); ".  "; MCAT$(B-6,A)
50280 NEXT A
50285 PRINT :PRINT :PRINT :PRINT
50290 INPUT "          Press <RETURN> when ready to continue. ", B$
50295 GOTO 50115
50300 REM
50305 FCODE$(FT,FC,4) = MCAT$(B,1)
50310 RETURN
50315 REM
50320 PRINT :PRINT
50325 INPUT "     Invalid entry, press <RETURN> to try again. ", B$
50330 GOTO 50115
50335 REM
50340 REM
51100 REM ****************** DISTRIBUTION TYPES ********************************
51105 REM
51110 REM
51115 CLS
51120 PRINT :PRINT
51125 PRINT TAB(20) "FIXTURE DISTRIBUTION TYPES"
51130 PRINT :PRINT :PRINT
51135 PRINT TAB(20) "TYPE"; TAB(30) "DISTRIBUTION";
51140 PRINT TAB(51) "% UP"; TAB(61) "% DOWN"
51145 PRINT
51150 FOR A=1 TO 5
51155 PRINT TAB(21) A; TAB(30) DTYPE$(A,1);
51160 PRINT TAB(50) DTYPE$(A,2); TAB(61) DTYPE$(A,3)
51165 NEXT A
51170 PRINT :PRINT :PRINT
51175 INPUT "          Enter TYPE # for selection: ", FIXTDATA(FT,FC,2)
51180 IF FIXTDATA(FT,FC,2) < 1 OR FIXTDATA(FT,FC,2) > 5 THEN 51190
51185 RETURN
51190 PRINT
51195 INPUT "     Invalid entry, press <RETURN> to try again. ", B$
51200 GOTO 51115
51205 REM
51210 REM
54100 REM ****************** HARDCOPY AFR 88-15 INFO ***************************
54105 REM
54110 REM
54115 CLS
54120 PRINT TAB(23) "HARDCOPY -- AFR 88-15 FC LEVELS"
54125 PRINT :PRINT
54130 PRINT TAB(20) "This procedure will send the AFR 88-15"
54135 PRINT TAB(20) "information on FC level requirements "
54140 PRINT TAB(20) "stored in memory to the printer."
54145 PRINT :PRINT
54150 PRINT TAB(20) "Enter (1) to continue,
54155 PRINT TAB(20) "      (2) to return to Hardcopy Menu"
54160 PRINT TAB(20) :INPUT "     "; B
54165 IF B=1 THEN 54180
54170 IF B=2 THEN RETURN
54175 GOTO 54115
54180 PRINT :PRINT TAB(12);
54185 INPUT "Be sure your Printer is on, press <RETURN> when ready.", B$
54190 PRINT :PRINT
54195 PRINT TAB(32) "PRINTING"
```

```
54200 REM
54205 LPRINT :LPRINT
54210 LPRINT TAB(28) "AFR 88-15 FC REQUIREMENTS"
54215 LPRINT :LPRINT
54220 LPRINT TAB(15) "ROOM TYPE"; TAB(30) "ROOM USE"; TAB(55) "FC LEVEL"
54225 LPRINT
54230 FOR A=1 TO 36
54235 LPRINT TAB(18) A; TAB(30) RMUSE$(A); TAB(58) RMUSELEVEL(A)
54240 NEXT A
54245 PRINT :PRINT :PRINT TAB(12);
54250 INPUT "Do you want another copy (Y/N) "; B$
54255 IF B$="N" OR B$="n" THEN RETURN
54260 CLS
54265 PRINT :PRINT :PRINT :PRINT
54270 GOTO 54180
55100 REM ****************** HARDCOPY COLOR CHART ******************************
55105 REM
55110 REM
55115 CLS
55120 PRINT TAB(28) "HARDCOPY -- COLOR CHART"
55125 PRINT :PRINT :PRINT
55130 PRINT TAB(20) "This procedure will send the color chart"
55135 PRINT TAB(20) "that is stored in memory to the printer."
55140 PRINT :PRINT :PRINT
55145 PRINT TAB(20) "Enter (1) to continue,
55150 PRINT TAB(20) "      (2) to return to Hardcopy Menu"
55155 PRINT TAB(20) :INPUT "     "; B
55160 IF B=1 THEN 55175
55165 IF B=2 THEN RETURN
55170 GOTO 55115
55175 PRINT :PRINT TAB(12);
55180 INPUT "Be sure your Printer is on, press (RETURN) when ready.", B$
55185 PRINT :PRINT
55190 PRINT TAB(32) "PRINTING"
55195 REM
55200 LPRINT :LPRINT
55205 LPRINT TAB(28) "COLOR CHART INFORMATION"
55210 LPRINT :LPRINT
55215 LPRINT TAB(10) "TYPE #"; TAB(23) "BRAND"; TAB(38) "COLOR";
55220 LPRINT TAB(57) "REFLECTIVITY"
55225 LPRINT
55230 FOR A=1 TO 30
55235 LPRINT TAB(12) A; TAB(23) PTMAN$(A); TAB(38) PTCOLOR$(A);
55240 LPRINT TAB(60) PTREFL(A)
55245 NEXT A
55250 PRINT :PRINT :PRINT TAB(12);
55255 INPUT "Do you want another copy (Y/N) "; B$
55260 IF B$="N" OR B$="n" THEN RETURN
55265 CLS
55270 PRINT :PRINT :PRINT :PRINT
55275 GOTO 55175
57100 REM ****************** HARDCOPY FIXTURE CHOICES **************************
57105 REM
57110 REM
57115 CLS
57120 PRINT TAB(26) "HARDCOPY -- FIXTURE CHOICES"
57125 PRINT :PRINT :PRINT
57130 PRINT TAB(16) "This procedure will send a list of the fixture"
57135 PRINT TAB(16) "choices that are stored in memory to the printer."
57140 PRINT :PRINT :PRINT
57145 PRINT TAB(16) "Enter (1) to continue,
57150 PRINT TAB(16) "      (2) to return to Hardcopy Menu"
57155 PRINT TAB(16) :INPUT "     "; B
57160 IF B=1 THEN 57175
57165 IF B=2 THEN RETURN
```

```
57170 GOTO 57115
57175 PRINT :PRINT TAB(12);
57180 INPUT "Be sure your Printer is on, press <RETURN> when ready.", B$
57185 PRINT :PRINT
57190 PRINT TAB(32) "PRINTING"
57195 REM
57200 LPRINT TAB(28) "FIXTURE CHOICES"
57205 LPRINT :LPRINT
57210 FOR A=1 TO 5
57215 LPRINT TAB(8) SOURCE$(A,1); " Fixtures"
57220 LPRINT
57225 LPRINT TAB(8) "FILE #"; TAB(18) "MAKE";
57230 LPRINT TAB(31) "MODEL #"; TAB(45) "MAINT.";
57235 LPRINT TAB(58) "DIST."; TAB(68) "S/MH"
57240 LPRINT TAB(44) "CATEGORY"; TAB(58) "TYPE"
57245 LPRINT
57250 FOR B=1 TO 10
57255 LPRINT TAB(8) FCODE$(A,B,1); TAB(18) FCODE$(A,B,2);
57260 LPRINT TAB(31) FCODE$(A,B,3); TAB(47) FCODE$(A,B,4);
57265 LPRINT TAB(59) FIXTDATA(A,B,2); TAB(68) FIXTDATA(A,B,1)
57270 NEXT B
57275 LPRINT :LPRINT :LPRINT
57280 IF A <> 3 THEN 57295
57285 LPRINT :LPRINT :LPRINT :LPRINT
57290 LPRINT :LPRINT :LPRINT :LPRINT
57295 NEXT A
57300 PRINT :PRINT :PRINT TAB(12);
57305 INPUT "Do you want another copy (Y/N) "; B$
57310 IF B$="N" OR B$="n" THEN RETURN
57315 CLS
57320 PRINT :PRINT :PRINT :PRINT
57325 GOTO 57175
58100 REM ****************** HARDCOPY LAMP CHOICES ****************************
58105 REM
58110 REM
58115 CLS
58120 PRINT TAB(28) "HARDCOPY -- LAMP CHOICES"
58125 PRINT :PRINT :PRINT
58130 PRINT TAB(16) "This procedure will send a list of the lamp"
58135 PRINT TAB(16) "choices that are stored in memory to the printer."
58140 PRINT :PRINT :PRINT
58145 PRINT TAB(16) "Enter (1) to continue,
58150 PRINT TAB(16) "      (2) to return to Hardcopy Menu"
58155 PRINT TAB(16) :INPUT "     "; B
58160 IF B=1 THEN 58175
58165 IF B=2 THEN RETURN
58170 GOTO 58115
58175 PRINT :PRINT TAB(12);
58180 INPUT "Be sure your Printer is on, press <RETURN> when ready.", B$
58185 PRINT :PRINT
58190 PRINT TAB(32) "PRINTING"
58195 REM
58200 LPRINT TAB(34) "LAMP CHOICES"
58205 LPRINT :LPRINT
58210 FOR A=1 TO 5
58215 LPRINT TAB(8) SOURCE$(A,1); " Lamps"
58220 LPRINT
58225 LPRINT TAB(12) "FILE #"; TAB(22) "CODE";
58230 LPRINT TAB(37) "WATTS"; TAB(48) "INITIAL"; TAB(61) "MAINT."
58235 LPRINT TAB(48) "LUMENS"; TAB(61) "LUMENS"
58240 LPRINT
58245 FOR B=1 TO 10
58250 LPRINT TAB(12) LCODE$(A,B,1); TAB(22) LCODE$(A,B,2);
58255 LPRINT TAB(37) LAMPDATA(A,B,1); TAB(48) LAMPDATA(A,B,2);
58260 LPRINT TAB(61) LAMPDATA(A,B,3)
```

```
58265 NEXT B
58270 LPRINT :LPRINT :LPRINT
58275 IF A <> 3 THEN 58290
58280 LPRINT :LPRINT :LPRINT :LPRINT
58285 LPRINT :LPRINT :LPRINT :LPRINT
58290 NEXT A
58295 PRINT :PRINT :PRINT TAB(12);
58300 INPUT "Do you want another copy (Y/N) "; B$
58305 IF B$="N" OR B$="n" THEN RETURN
58310 CLS
58315 PRINT :PRINT :PRINT :PRINT
58320 GOTO 58175
60100 REM ****************** HARDCOPY FIXTURE CU TABLES ************************
60105 REM
60110 REM
60115 CLS
60120 PRINT TAB(22) "HARDCOPY -- FIXTURE CU TABLES"
60125 PRINT :PRINT
60130 PRINT TAB(20) "This procedure will let you choose"
60135 PRINT TAB(20) "a specific Fixture & CU table that is"
60140 PRINT TAB(20) "stored in memory to send to the printer."
60145 PRINT :PRINT
60150 PRINT TAB(20) "Enter (1) to continue,
60155 PRINT TAB(20) "      (2) to return to Hardcopy Menu"
60160 PRINT TAB(20) :INPUT "      "; B
60165 IF B=1 THEN 60165
60170 IF B=2 THEN RETURN
60175 GOTO 60115
60180 REM
60185 CLS
60190 PRINT :PRINT
60195 PRINT TAB(30) "PRINT FIXTURE CU TABLES"
60200 PRINT :PRINT :PRINT
60205 PRINT TAB(22) "CHOICE"; TAB(40) "FIXTURE TYPE"
60210 PRINT :PRINT
60215 FOR A=1 TO 5
60220 PRINT TAB(22) A; TAB(40) SOURCE$(A,1); TAB(62) SOURCE$(A,2)
60225 NEXT A
60230 PRINT :PRINT
60235 PRINT
60240 PRINT TAB(22) A; TAB(40) "RETURN TO HARDCOPY MENU"
60245 PRINT :PRINT :PRINT
60250 INPUT "              Enter CHOICE # for Fixture selection: ", FT
60255 IF FT < 1 OR FT > 6 GOTO 60835
60260 REM
60265 IF FT = 6 THEN RETURN
60270 REM
60275 REM
60280 CLS
60285 PRINT TAB(21) "UPDATE FIXTURE FILES:  "; SOURCE$(FT,1); " Fixtures"
60290 PRINT :PRINT
60295 PRINT "CHOICE"; TAB(12) "FILE #"; TAB(23) "MAKE"; TAB(37) "MODEL #";
60300 PRINT TAB(51) "MAINT."; TAB(64) "DIST."; TAB(74) "S/MH"
60305 PRINT TAB(50) "CATEGORY"; TAB(64) "TYPE"
60310 PRINT
60315 FOR A=1 TO 10
60320 PRINT TAB(3) A; TAB(12) FCODE$(FT,A,1); TAB(23) FCODE$(FT,A,2);
60325 PRINT TAB(37) FCODE$(FT,A,3); TAB(53) FCODE$(FT,A,4);
60330 PRINT TAB(65) FIXTDATA(FT,A,2); TAB(74) FIXTDATA(FT,A,1)
60335 NEXT A
60340 PRINT :PRINT
60345 INPUT "     To print fixture data, enter CHOICE # or (0) to quit: ", FC
60350 IF FC = 0 GOTO 60185
60355 IF FC < 0 OR FC > 10 GOTO 60835
60360 REM
```

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60365 REM
60370 IF FT=1 THEN 60395
60375 IF FT=2 THEN 60450
60380 IF FT=3 THEN 60590
60385 IF FT=4 THEN 60645
60390 IF FT=5 THEN 60700
60395 IF FC=1 THEN OPEN "I", #1, "A:INCU1.DAT"
60400 IF FC=2 THEN OPEN "I", #1, "A:INCU2.DAT"
60405 IF FC=3 THEN OPEN "I", #1, "A:INCU3.DAT"
60410 IF FC=4 THEN OPEN "I", #1, "A:INCU4.DAT"
60415 IF FC=5 THEN OPEN "I", #1, "A:INCU5.DAT"
60420 IF FC=6 THEN OPEN "I", #1, "A:INCU6.DAT"
60425 IF FC=7 THEN OPEN "I", #1, "A:INCU7.DAT"
60430 IF FC=8 THEN OPEN "I", #1, "A:INCU8.DAT"
60435 IF FC=9 THEN OPEN "I", #1, "A:INCU9.DAT"
60440 IF FC=10 THEN OPEN "I", #1, "A:INCU10.DAT"
60445 GOTO 60505
60450 IF FC=1 THEN OPEN "I", #1, "A:FLCU1.DAT"
60455 IF FC=2 THEN OPEN "I", #1, "A:FLCU2.DAT"
60460 IF FC=3 THEN OPEN "I", #1, "A:FLCU3.DAT"
60465 IF FC=4 THEN OPEN "I", #1, "A:FLCU4.DAT"
60470 IF FC=5 THEN OPEN "I", #1, "A:FLCU5.DAT"
60475 IF FC=6 THEN OPEN "I", #1, "A:FLCU6.DAT"
60480 IF FC=7 THEN OPEN "I", #1, "A:FLCU7.DAT"
60485 IF FC=8 THEN OPEN "I", #1, "A:FLCU8.DAT"
60490 IF FC=9 THEN OPEN "I", #1, "A:FLCU9.DAT"
60495 IF FC=10 THEN OPEN "I", #1, "A:FLCU10.DAT"
60500 REM
60505 FOR D=1 TO 2
60510 FOR C=1 TO 4
60515 FOR B=1 TO 10
60520 INPUT#1, CU1(B,C,D)
60525 NEXT B
60530 NEXT C
60535 NEXT D
60540 FOR D=1 TO 2
60545 FOR C=1 TO 3
60550 FOR B=1 TO 10
60555 INPUT#1, CU2(B,C,D)
60560 NEXT B
60565 NEXT C
60570 NEXT D
60575 CLOSE #1
60580 GOTO 60865
60585 REM
60590 IF FC=1 THEN OPEN "I", #1, "A:MVCU1.DAT"
60595 IF FC=2 THEN OPEN "I", #1, "A:MVCU2.DAT"
60600 IF FC=3 THEN OPEN "I", #1, "A:MVCU3.DAT"
60605 IF FC=4 THEN OPEN "I", #1, "A:MVCU4.DAT"
60610 IF FC=5 THEN OPEN "I", #1, "A:MVCU5.DAT"
60615 IF FC=6 THEN OPEN "I", #1, "A:MVCU6.DAT"
60620 IF FC=7 THEN OPEN "I", #1, "A:MVCU7.DAT"
60625 IF FC=8 THEN OPEN "I", #1, "A:MVCU8.DAT"
60630 IF FC=9 THEN OPEN "I", #1, "A:MVCU9.DAT"
60635 IF FC=10 THEN OPEN "I", #1, "A:MVCU10.DAT"
60640 GOTO 60755
60645 IF FC=1 THEN OPEN "I", #1, "A:MHCU1.DAT"
60650 IF FC=2 THEN OPEN "I", #1, "A:MHCU2.DAT"
60655 IF FC=3 THEN OPEN "I", #1, "A:MHCU3.DAT"
60660 IF FC=4 THEN OPEN "I", #1, "A:MHCU4.DAT"
60665 IF FC=5 THEN OPEN "I", #1, "A:MHCU5.DAT"
60670 IF FC=6 THEN OPEN "I", #1, "A:MHCU6.DAT"
60675 IF FC=7 THEN OPEN "I", #1, "A:MHCU7.DAT"
60680 IF FC=8 THEN OPEN "I", #1, "A:MHCU8.DAT"
60685 IF FC=9 THEN OPEN "I", #1, "A:MHCU9.DAT"
```

```
60650 IF FC=10 THEN OPEN "I", #1, "A:MHCU10.DAT"
60655 GOTO 60755
60700 IF FC=1 THEN OPEN "I", #1, "A:HPCU1.DAT"
60705 IF FC=2 THEN OPEN "I", #1, "A:HPCU2.DAT"
60710 IF FC=3 THEN OPEN "I", #1, "A:HPCU3.DAT"
60715 IF FC=4 THEN OPEN "I", #1, "A:HPCU4.DAT"
60720 IF FC=5 THEN OPEN "I", #1, "A:HPCU5.DAT"
60725 IF FC=6 THEN OPEN "I", #1, "A:HPCU6.DAT"
60730 IF FC=7 THEN OPEN "I", #1, "A:HPCU7.DAT"
60735 IF FC=8 THEN OPEN "I", #1, "A:HPCU8.DAT"
60740 IF FC=9 THEN OPEN "I", #1, "A:HPCU9.DAT"
60745 IF FC=10 THEN OPEN "I", #1, "A:HPCU10.DAT"
60750 REM
60755 FOR C=1 TO 4
60760 FOR B=1 TO 10
60765 INPUT#1, CU3(B,C,1)
60770 NEXT B
60775 NEXT C
60780 FOR D=1 TO 2
60785 FOR C=1 TO 3
60790 FOR B=1 TO 10
60795 INPUT#1, CU4(B,C,D)
60800 NEXT B
60805 NEXT C
60810 NEXT D
60815 REM
60820 CLOSE #1
60825 GOTO 61090
60830 REM
60835 CLS
60840 PRINT "     Invalid entry, please try again."
60845 PRINT
60850 INPUT "     Press <RETURN> when ready. ", B$
60855 GOTO 60185
60860 REM ********** INC.FLU FIXTURE CU TABLE PRINT
60865 CLS
60870 PRINT :PRINT :PRINT :PRINT :PRINT TAB(12);
60875 INPUT "Be sure your Printer is on, press <RETURN> when ready.", B$
60880 PRINT :PRINT
60885 PRINT TAB(32) "PRINTING"
60890 REM
60895 LPRINT TAB(5) "FIXTURE MAKE:  "; FCODE$(FT,FC,2);
60900 LPRINT TAB(50) "FIXTURE MODEL:  "; FCODE$(FT,FC,3)
60905 LPRINT :LPRINT
60910 LPRINT TAB(5) "CFR"; TAB(46) CFR(2)
60915 LPRINT TAB(5) "CCR"; TAB(18) CCR(1); TAB(37) CCR(2);
60920 LPRINT TAB(54) CCR(3); TAB(69) CCR(4)
60925 REM
60930 LPRINT TAB(5) "CWR";
60935 LPRINT TAB(12) CWR(1); CWR(2); CWR(3); CWR(4);
60940 LPRINT TAB(31) CWR(1); CWR(2); CWR(3); CWR(4);
60945 LPRINT TAB(50) CWR(2); CWR(3); CWR(4);
60950 LPRINT TAB(65) CWR(2); CWR(4); CWR(4)
60955 LPRINT
60960 REM
60965 LPRINT TAB(5) "RCR"
60970 REM
60975 FOR A=1 TO 10
60980 LPRINT TAB(5) A;
60985 LPRINT TAB(12) "";
60990 FOR B=1 TO 4
60995 LPRINT CU1(A,B,1);
61000 NEXT B
61005 LPRINT TAB(31) "";
61010 FOR B=1 TO 4
```

```
61015 LPRINT CU1(A,B,2);
61020 NEXT B
61025 LPRINT TAB(50) "";
61030 FOR B=1 TO 3
61035 LPRINT CU2(A,B,1);
61040 NEXT B
61045 LPRINT TAB(65) "";
61050 FOR B=1 TO 2
61055 LPRINT CU2(A,B,2);
61060 NEXT B
61065 LPRINT CU2(A,3,2)
61070 NEXT A
61075 REM
61080 GOTO 60185
61085 REM ********** MV/MH/HPS FIXTURE CU TABLE PRINT
61090 CLS
61095 PRINT :PRINT TAB(12);
61100 INPUT "Be sure your Printer is on, press <RETURN> when ready.", B$
61105 PRINT :PRINT
61110 PRINT TAB(32) "PRINTING"
61115 REM
61120 LPRINT TAB(5) "FIXTURE MAKE:  "; FCODE$(FT,FC,2);
61125 LPRINT TAB(45) "FIXTURE MODEL:  "; FCODE$(FT,FC,3)
61130 LPRINT :LPRINT
61135 LPRINT TAB(10) "CFR"; TAB(36) CFR(2)
61140 LPRINT TAB(10) "CCR"; TAB(26) CCR(1); TAB(44) CCR(3);
61145 LPRINT TAB(60) CCR(5)
61150 REM
61155 LPRINT TAB(10) "CWR";
61160 LPRINT TAB(20) CWR(1); CWR(2); CWR(3); CWR(4);
61165 LPRINT TAB(40) CWR(2); CWR(3); CWR(4);
61170 LPRINT TAB(56) CWR(2); CWR(4); CWR(4)
61175 LPRINT
61180 REM
61185 LPRINT TAB(10) "BCR"
61190 REM
61195 FOR A=1 TO 10
61200 LPRINT TAB(10) A;
61205 LPRINT TAB(20) "";
61210 FOR B=1 TO 4
61215 LPRINT CU3(A,B,1);
61220 NEXT B
61225 LPRINT TAB(40) "";
61230 FOR B=1 TO 3
61235 LPRINT CU4(A,B,1);
61240 NEXT B
61245 LPRINT TAB(56) "";
61250 FOR B=1 TO 2
61255 LPRINT CU4(A,B,2);
61260 NEXT B
61265 LPRINT CU4(A,3,2)
61270 NEXT A
61275 REM
61280 GOTO 60185
61285 REM
61290 REM
```

Appendix B: Subroutine Listings

This appendix contains the listings of major subroutines that make up the second and third sub-programs of LIGHT1A. The first sub-program is broken into only two major areas neither of which depend on the other. Because of this, the first sub-program's breakdown is not included in this appendix. Listed in this appendix will be the subroutine's starting line number, and the subroutine's function (what the subroutine does).

Program 1 -- Major Subroutines

Line Number	Subroutine Function
5100	Menu -- B Screen
10100	New Room w/o Tables Screen
11100	New Room w/ Tables Screen
12100	w/o Tables Introduction Screen
13100	w/ Tables Introduction Screen
20100	Screen 1, Room Information
21100	Screen 2, Luminaire Information
22100	Screen 3, Final Design Calcs.
23100	Screen 4, Final Design Calcs.
24100	Effective Reflectances Calcs.
25100	Luminaire Dirt Depreciation Calcs.
25250	Room Surface Dirt Depreciation Calcs.
25370	Lamp Lumen Depreciation Calcs.
25415	Total Light Loss Factor Calcs.
26100	Charted CU Values
27640	Floor Coefficient Calcs.
27800	Final CU Value Calcs.
27845	Non-stored CU Tables
29100	Number of Fixture Calcs.
30100	Actual FC Level Calcs.
40100	Room Reference Data
41100	AFR 88-15 FC Levels
42100	Room Dimensions and RCR Calcs.
43100	Surface Reflectances
44100	Room Dirt Conditions
45100	Light Source Types
47100	Fixture Choices
48100	Lamp Choices
50100	Non-tabled Room Information
50115	Room Use w/o Tables
50190	Room Reflectances w/o Tables
51100	Non-stored Fixture Information
54100	Maintenance Categories
55100	Distribution Types
57100	Hardcopy

Program 2 -- Major Subroutines

Line Number	Subroutine Function
4100	Menu -- C1 Screen
5100	Menu -- C2 Screen
6100	Menu -- C3 Screen
29100	Update AFR 88-15 FC Levels
30100	Update Color Chart
32100	Update Fixture Files
34100	Update Lamp Files
36100	CU Chart Input (Inc. & Fluor. Fixtures)
37100	CU Chart Input (MV, MH & HPS Fixtures)
50100	Maintenance Categories
51100	Distribution Types
54100	Hardcopy AFR 88-15 Information
55100	Hardcopy Color Chart
57100	Hardcopy Fixture Choices
58100	Hardcopy Lamp Choices
60100	Hardcopy Fixture CU Chart

Appendix C: Hardcopies of Changeable Data Files

This appendix contains a printout of the reference data contained in the four "changeable" data files. Each data file title and starting page number is listed below. These listings can be produced by using the third sub-program in LIGHT1A.

AFR 88-15 FC REQUIREMENTS

ROOM TYPE	ROOM USE	FC LEVEL
1	Designer's Choice	0
2	No Designation	30
3	No Designation	50
4	No Designation	70
5	No Designation	100
6	No Designation	150
7	Accounting rooms	75
8	Auditoriums	20
9	Cafeterias	25
10	Computer rooms	50
11	Conference rooms	30
12	Corridors	10
13	Drafting rooms	75
14	Elevator mach. rms	15
15	EM. Generator rooms	15
16	Garage Enterence	30
17	General Offices	50
18	Janitor's Closet	5
19	Kitchens	70
20	Lobbies	15
21	Lounges	15
22	Mechanical rooms	15
23	Stairways	20
24	Storage rooms	5
25	Swichgear rooms	15
26	Toilets	20
27	Transformer Vaults	15
28	Warehousing:	0
29	Inactive	5
30	Active-bulk	10
31	Rack	20
32	Bin	5
33	Material Handling:	0
34	Control Centers	30
35	Load/Unload	20
36	Conveyor Lines	10

COLOR CHART INFORMATION

TYPE #	BRAND	COLOR	REFLECTIVITY
1	DEFAULT	CEILING	80
2	DEFAULT	WALL	70
3	DEFAULT	FLOOR	20
4			0
5			0
6	DURREL	Cameo White	86
7	DURREL	Winter White	83
8	DURREL	Lemon	84
9	DURREL	Manilla Beige	77
10	DURREL	Pink Marble	74
11	DURREL	Butte Orange	31
12	DURREL	Lavender Rose	39
13	DURREL	Pale Violet	74
14	DURREL	Violet Gray	52
15	DURREL	Blue Daisy	62
16	DURREL	Iceburg	77
17	DURREL	Crayon Blue	20
18	DURREL	Colonial Green	69
19	DURREL	Pastel Green	69
20	DURREL	Mint Haze	75
21	DURREL	Silver Lining	70
22	DURREL	Dawn Gray	77
23	DURREL	Sand Tan	68
24	DURREL	Ocean Sand	63
25	DURREL	Cinnamon	16
26			0
27			0
28			0
29			0
30			0

FIXTURE CHOICES

Incandescent Fixtures

FILE #	MAKE	MODEL #	MAINT. CATEGORY	DIST. TYPE	S/MH
I-01				0	0
I-02	Lithonia	A6A-AR	V	5	1.1
I-03				0	0
I-04	Lithonia	A8A-AR	V	5	1
I-05				0	0
I-06				0	0
I-07				0	0
I-08				0	0
I-09				0	0
I-10				0	0

Fluorescent Fixtures

FILE #	MAKE	MODEL #	MAINT. CATEGORY	DIST. TYPE	S/MH
F-01	Lithonia	2GS-240	V	5	1.4
F-02	Lithonia	2GS-340	V	5	1.3
F-03	Lithonia	2GS-440	V	5	1.3
F-04				0	0
F-05				0	0
F-06				0	0
F-07				0	0
F-08				0	0
F-09				0	0
F-10				0	0

Mercury Vapor Fixtures

FILE #	MAKE	MODEL #	MAINT. CATEGORY	DIST. TYPE	S/MH
MV-01	Hi-Tek	TXL-100H-ARW	IV	5	1.7
MV-02	Hi-Tek	TXL-175-ARW	IV	5	1.6
MV-03	Hi-Tek	TXL-250H-ARW	IV	5	1.6
MV-04				0	0
MV-05				0	0
MV-06				0	0
MV-07				0	0
MV-08				0	0
MV-09				0	0
MV-10				0	0

Metal Halide Fixtures

FILE #	MAKE	MODEL #	MAINT. CATEGORY	DIST. TYPE	S/MH
MH-01	Hi-Tek	TXL-175M-ARW	IV	5	1.8
MH-02	Hi-Tek	TXL-250M-ARW	IV	5	1.7
MH-03				0	0
MH-04				0	0
MH-05				0	0
MH-06				0	0
MH-07				0	0
MH-08				0	0
MH-09				0	0
MH-10				0	0

High Pressure Sodium Fixtures

FILE #	MAKE	MODEL #	MAINT. CATEGORY	DIST. TYPE	S/MH
H-01	Hi-Tek	TX-250S-ARW	IV	5	2
H-02	Hi-Tek	TX-400S-ARW	IV	5	1.7
H-03				0	0
H-04				0	0
H-05				0	0
H-06				0	0
H-07				0	0
H-08				0	0
H-09				0	0
H-10				0	0

LAMP CHOICES

Incandescent Lamps

FILE #	CODE	WATTS	INITIAL LUMENS	MAINT. LUMENS
I-21	75A	75	1190	1190
I-22	75A/CL	75	1190	1190
I-23	100A	100	1750	1750
I-24	100A/CL	100	1750	1750
I-25	150A	150	2880	2880
I-26	150A/CL	150	2880	2880
I-27	200A	200	4010	4010
I-28	200A/CL	200	4010	4010
I-29	300M	300	6360	6360
I-30		0	0	0

Fluorescent Lamps

FILE #	CODE	WATTS	INITIAL LUMENS	MAINT. LUMENS
F-21	F40CW/RS/WM	35	2850	2510
F-22	F40WW/RS/WM	35	2850	2510
F-23	F40CW	40	3150	2770
F-24	F40WW	40	3150	2770
F-25	F40CW/U/6	40	2900	2525
F-26	F96T12/CW/WM	60	5600	5150
F-27	F96T12/WW/WM	60	5600	5150
F-28	F96T12/CW	75	6300	5800
F-29	F96T12/WW	75	6300	5800
F-30		0	0	0

Mercury Vapor Lamps

FILE #	CODE	WATTS	INITIAL LUMENS	MAINT. LUMENS
MV-21	H75DX43	75	2800	2250
MV-22		0	0	0
MV-23	H100DX38-4	100	4200	3530
MV-24		0	0	0
MV-25	H175DX39-22	175	8600	7650
MV-26		0	0	0
MV-27	H250DX37-5	250	12100	10400
MV-28	H400DX33-1	400	22500	19100
MV-29	H700DX35-18	700	42000	33600
MV-30	H1000DX36-15	1000	63000	47500

Metal Halide Lamps

FILE #	CODE	WATTS	INITIAL LUMENS	MAINT. LUMENS
MH-21	MV175/U	175	14000	10800
MH-22	MV175/C/U	175	14000	10200
MH-23	MV250/U	250	20500	17000
MH-24	MV250/C/U	250	20500	16000
MH-25	MV400/U	400	34000	25600
MH-26	MV400/C/U	400	34000	24600
MH-27	MV1000/U	1000	110000	88000
MH-28	MV1000/C/U	1000	105000	83000
MH-29	MV1500/HBU/E	1500	155000	140000
MH-30	MV1500/HBD/E	1500	155000	140000

High Pressure Sodium Lamps

FILE #	CODE	WATTS	INITIAL LUMENS	MAINT. LUMENS
H-21	LU50	50	3300	2970
H-22		0	0	0
H-23	LU70	70	5800	5220
H-24		0	0	0
H-25	LU100	100	9500	8550
H-26	LU150/55	150	16000	14400
H-27	LU200	200	22000	19800
H-28	LU250	250	27500	24750
H-29	LU400	400	50000	45000
H-30	LU1000	1000	140000	126000

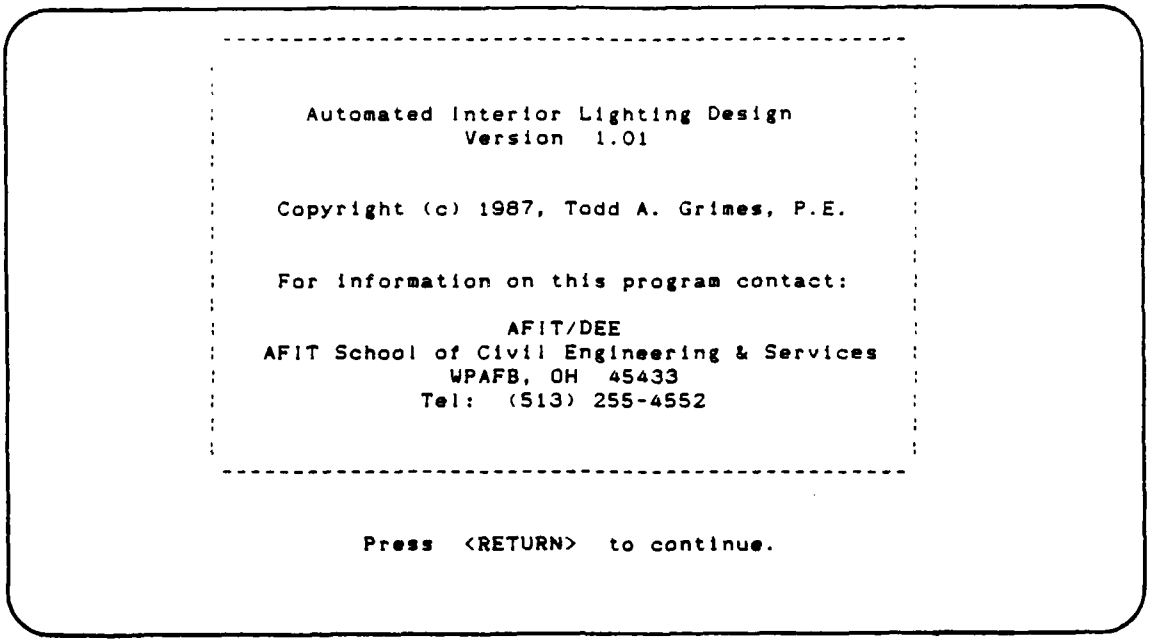
Appendix D: Entire Screen Displays for Chapter IV Problem

This appendix contains all the "screens" that the design engineer would see generated by LIGHT1A while performing the same lighting design that was done in Chapter IV.

If on a computer that is IBM compatible, the design engineer would place the PROGRAM DISK in the A disk drive of the computer and enter "BASICA LIGHT1A" at the DOS prompt.

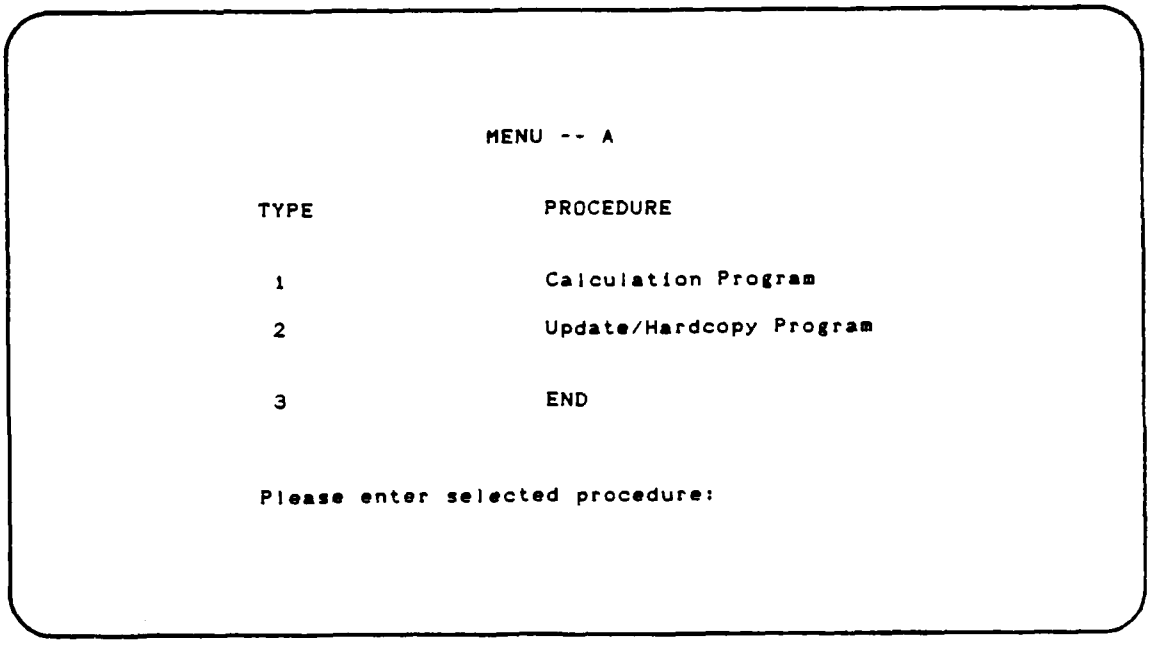
If the design engineer is using the Wang pc computer, he simply would install BASIC into the computer's memory, place the PROGRAM DISK in the A drive, and enter "A:LIGHT1A" at the BASIC prompt.

Screen D.1 is the first screen that would appear. Subsequent screens and the appropriate responses are shown.



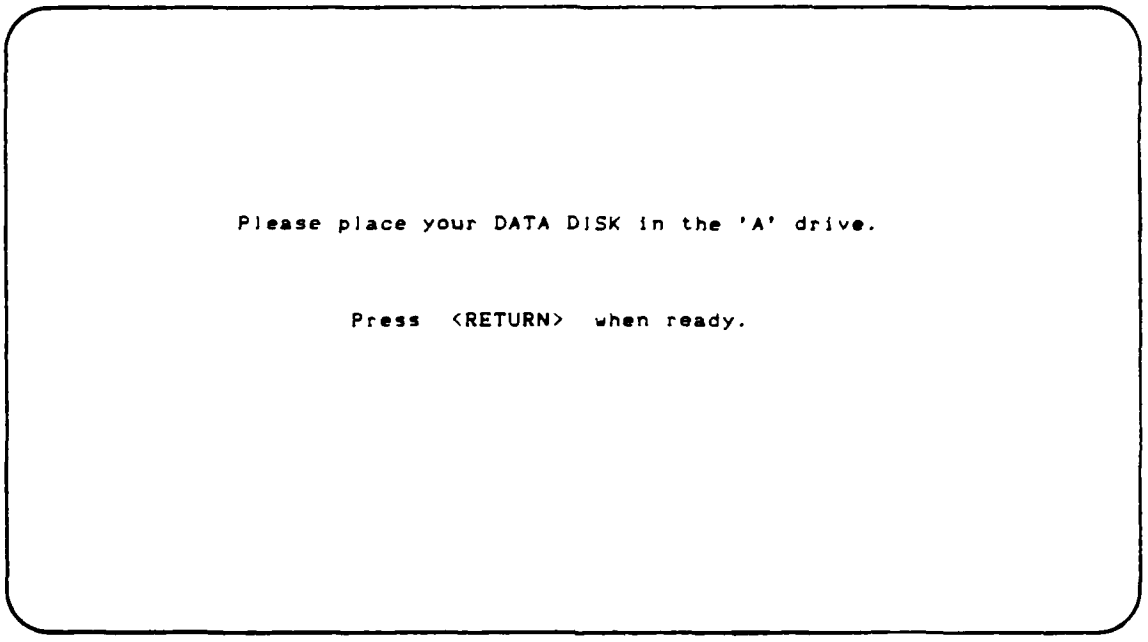
Screen D.1

RESPONSE: Hit <RETURN>



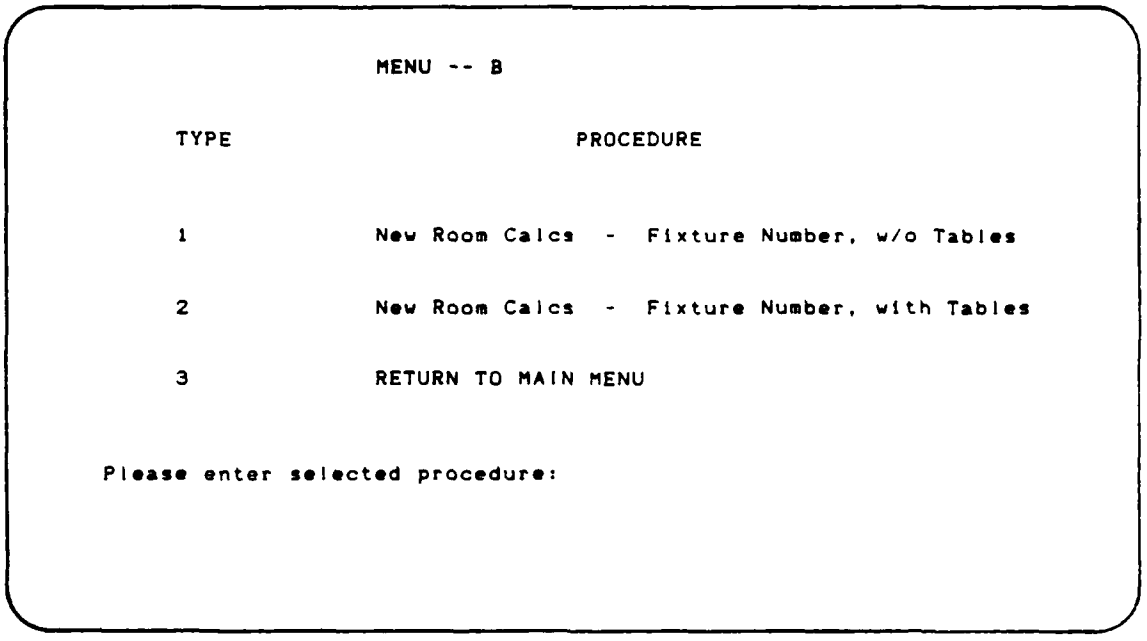
Screen D.2

RESPONSE: Enter 1



Screen D.3

RESPONSE: Insert Data Disk in Drive A, Hit <RETURN>



Screen D.4

RESPONSE: Enter 2

```
                    INSTRUCTIONS -- WITH TABLES


        This procedure will give you screens that must be
        filled out.  One screen will be for the room
        information, the other screen will be for the fixture
        information.  To fill out the screens, simply enter
        the number to the right of the major topic desired.
        Tables will be given to you when possible allowing
        you to choose the best answer for your situation.


        Enter (1) to continue,
              (2) to return to MENU -- B
            ?
```

Screen D.5

RESPONSE: Enter 1

```
                    ROOM INFORMATION REQUIREMENTS

   (1) REFERENCE DATA:

       Building #          Room #                      Iteration: 1

   (2) Room Use:                          FC Requirements: 0

   (3) ROOM DIMENSIONS:

                                                  Ceiling Height: 0
       Length: 0           Perimeter: 0           Fixture Height: 0
       Width:  0           Area:      0           Working Height: 0

   (4) ROOM REFLECTANCES:

       Ceiling Color:                         Reflectance: 0 %
       Wall Color:                            Reflectance: 0 %
       Floor Color:                           Reflectance: 0 %

   (5) Room Condition:                        Cleaning Cycle:  0  months


Enter selection # (x) for data input, or (0) to continue:
```

Screen D.6

RESPONSE: Enter 1

```
Please enter the building number: None

Please enter room number:         None

This is iteration # 1  for this room -- Correct (Y/N) ?
```

Screen D.7

RESPONSE: Enter proper responses shown, then Enter Y

```
                    ROOM INFORMATION REQUIREMENTS

(1) REFERENCE DATA:

    Building # None      Room # None                  Iteration: 1

(2) Room Use:                              FC Requirements: 0

(3) ROOM DIMENSIONS:

                                                  Ceiling Height: 0
    Length: 0            Perimeter: 0             Fixture Height: 0
    Width:  0            Area:      0             Working Height: 0

(4) ROOM REFLECTANCES:

    Ceiling Color:                         Reflectance: 0 %
    Wall Color:                            Reflectance: 0 %
    Floor Color:                           Reflectance: 0 %

(5) Room Condition:                        Cleaning Cycle:  0  months

Enter selection # (x) for data input, or (0) to continue:
```

Screen D.8

RESPONSE: Enter **2**

FOOTCANDLE LEVEL REQUIREMENTS

You must select the room's actual use along with its corresponding FC level from the following table. This table comes from the AFR 88-15, and is split into three screens. To enter your own FC level, choose #1 on the first screen.

Press <RETURN> to continue.

Screen D.9

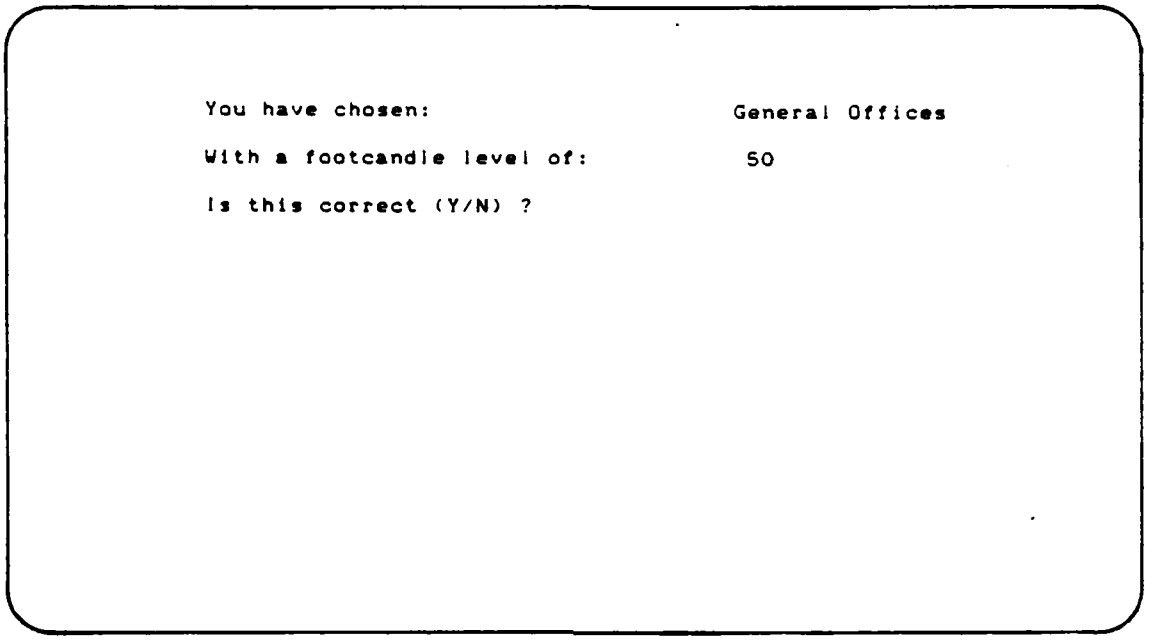
RESPONSE: Hit <RETURN>

ROOM TYPE	ROOM USE	FC LEVEL
13	Drafting rooms	75
14	Elevator mach. rms	15
15	EM. Generator rooms	15
16	Garage Enterence	30
17	General Offices	50
18	Janitor's Closet	5
19	Kitchens	70
20	Lobbies	15
21	Lounges	15
22	Mechanical rooms	15
23	Stairways	20
24	Storage rooms	5
25	OTHER	

Enter selected Room Type:

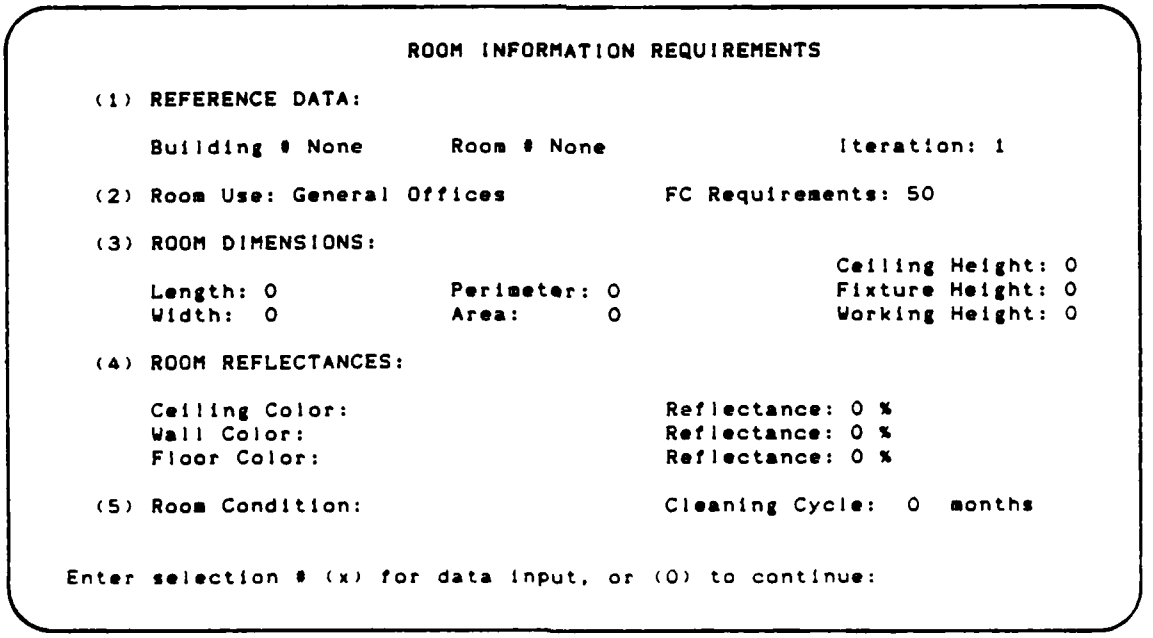
Screen D.10

RESPONSE: Enter **17** (note: one screen not shown)



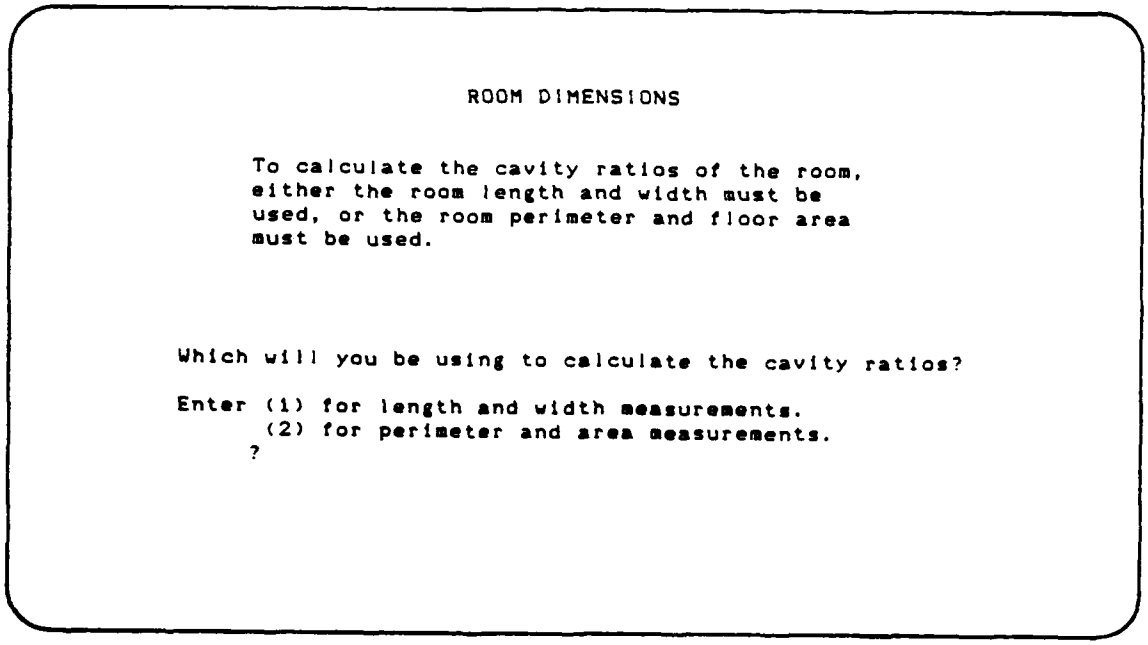
Screen D.11

RESPONSE: Enter **Y**



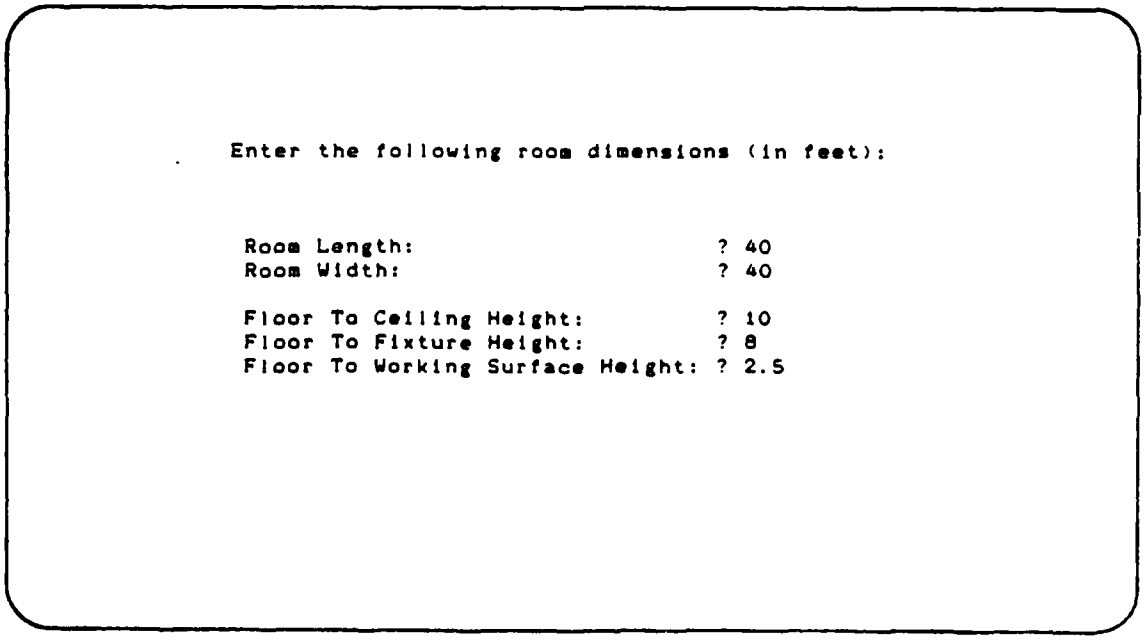
Screen D.12

RESPONSE: Enter **3**



Screen D.13

RESPONSE: Enter 1



Screen D.14

RESPONSE: Enter proper room dimensions

```
Please verify the following information:

    The Room Length:                          40 ft.
    The Room Width:                           40 ft.
    The Room Perimeter:                       160 ft.
    The Room Floor Area:                      1600 ft^2

    The Floor to Ceiling Height:              10 ft.
    The Floor to Fixture Height:              8 ft.
    The Floor to Working Surface Height:      2.5 ft.

Is everything correct (Y/N) ?
```

Screen D.15

RESPONSE: Enter **Y**

```
                    ROOM INFORMATION REQUIREMENTS
(1) REFERENCE DATA:

    Building # None      Room # None                  Iteration: 1

(2) Room Use: General Offices          FC Requirements: 50

(3) ROOM DIMENSIONS:

                                                    Ceiling Height: 10
    Length: 40           Perimeter: 160             Fixture Height: 8
    Width:  40           Area:      1600            Working Height: 2.5

(4) ROOM REFLECTANCES:

    Ceiling Color:                      Reflectance: 0 %
    Wall Color:                         Reflectance: 0 %
    Floor Color:                        Reflectance: 0 %

(5) Room Condition:                     Cleaning Cycle:  0  months

Enter selection # (x) for data input, or (0) to continue:
```

Screen D.16

RESPONSE: Enter **4**

SURFACE REFLECTANCES

You need to choose the color and reflectance ratings of the ceiling, the walls, and the floor. Following are 3 screens full of colors and their associated reflectances to make your choices from. Please enter the TYPE # in the sequence indicated.

Press <RETURN> to continue.

Screen D.17

RESPONSE: Hit <RETURN>

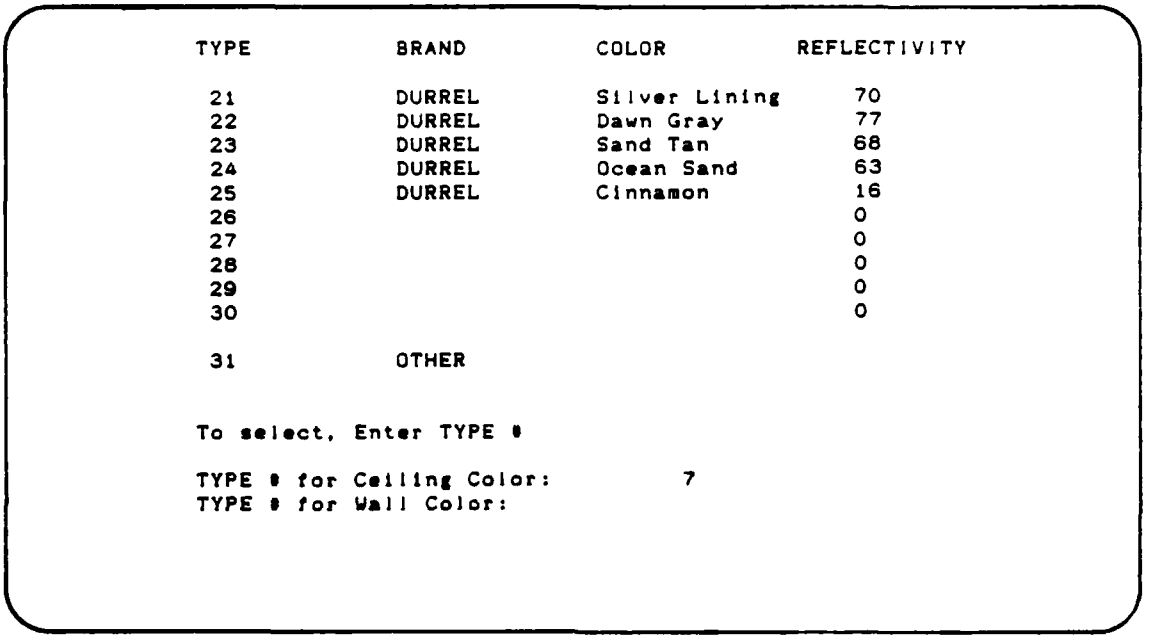
TYPE	BRAND	COLOR	REFLECTIVITY
1	DEFAULT	CEILING	80
2	DEFAULT	WALL	70
3	DEFAULT	FLOOR	20
4			0
5			0
6	DURREL	Cameo White	86
7	DURREL	Winter White	83
8	DURREL	Lemon	84
9	DURREL	Manilla Beige	77
10	DURREL	Pink Marble	74
11	OTHER		

To select, Enter TYPE #

TYPE # for Ceiling Color:

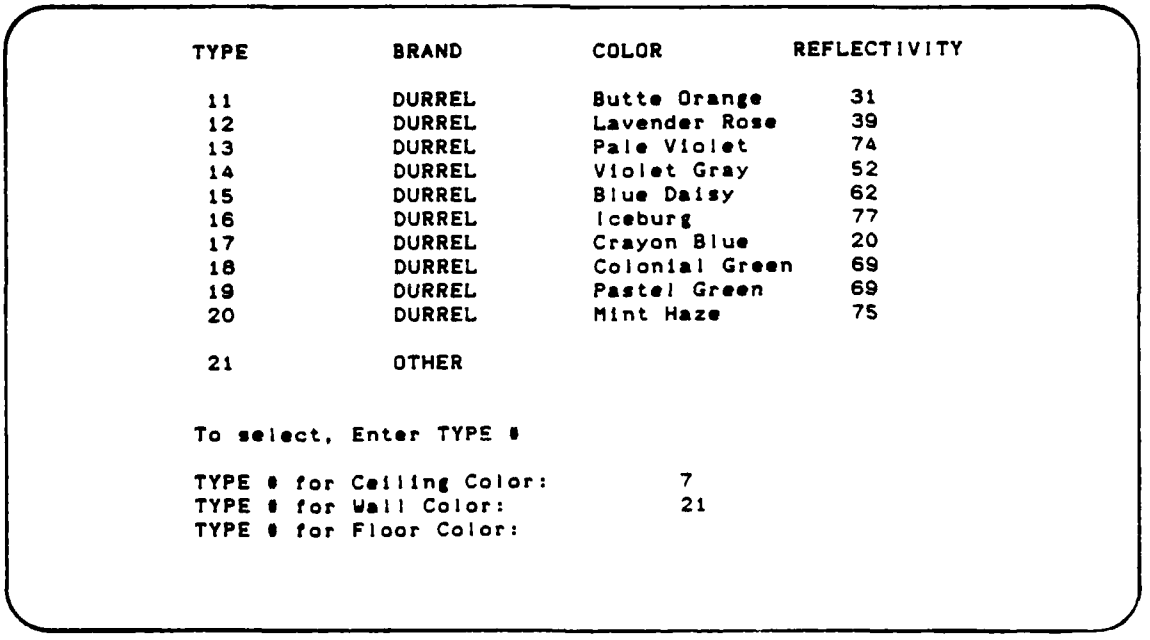
Screen D.18

RESPONSE: Enter **7**



Screen D.19

RESPONSE: Enter **21**



Screen D.20

RESPONSE: Enter **17**

```
You have chosen:

Winter White        with a 83 %  Reflectivity for the Ceiling.
Silver Lining       with a 70 %  Reflectivity for the Walls.
Crayon Blue         with a 20 %  Reflectivity for the Floor.

Are these all correct (Y/N) ?
```

Screen D.21

RESPONSE: Enter **Y**

```
                    ROOM INFORMATION REQUIREMENTS

(1) REFERENCE DATA:

    Building # None      Room # None                  Iteration: 1

(2) Room Use: General Offices            FC Requirements: 50

(3) ROOM DIMENSIONS:
                                                  Ceiling Height: 10
    Length: 40           Perimeter: 160           Fixture Height: 8
    Width:  40           Area:      1600          Working Height: 2.5

(4) ROOM REFLECTANCES:

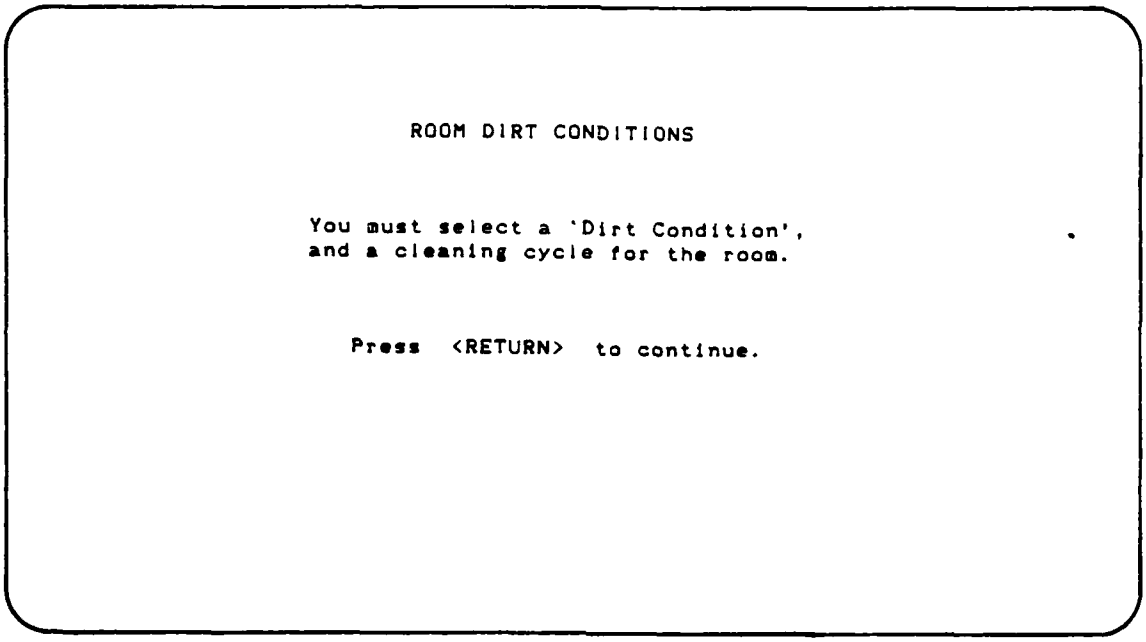
    Ceiling Color: Winter White          Reflectance: 83 %
    Wall Color:    Silver Lining         Reflectance: 70 %
    Floor Color:   Crayon Blue           Reflectance: 20 %

(5) Room Condition:                      Cleaning Cycle:  0  months

Enter selection # (x) for data input, or (0) to continue:
```

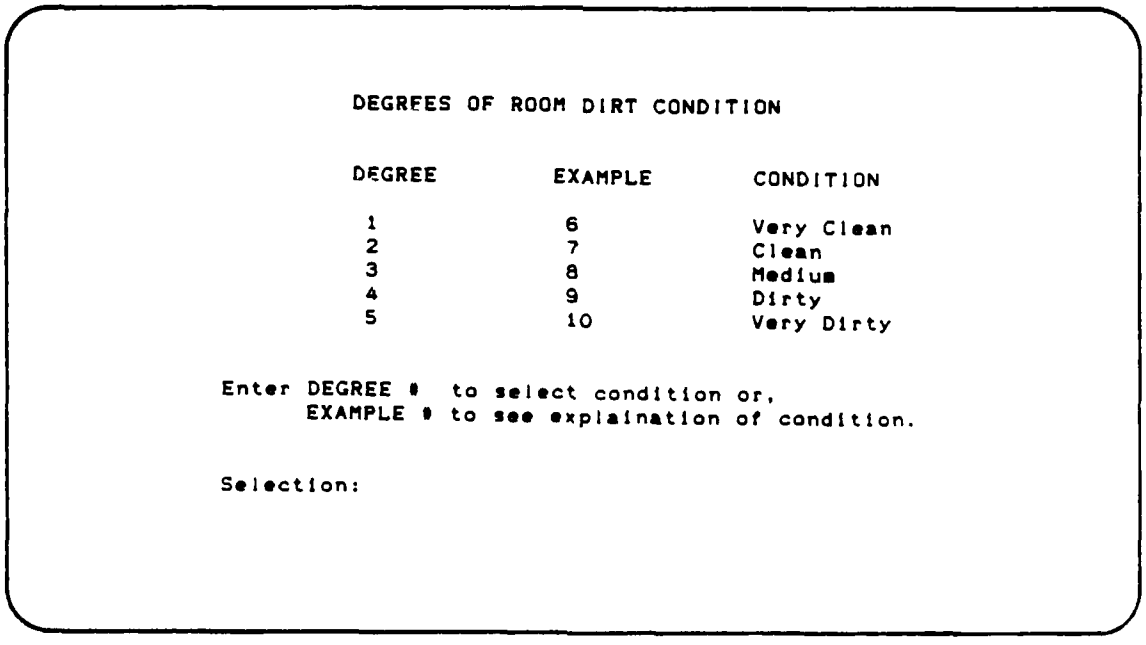
Screen D.22

RESPONSE: Enter **5**



Screen D.23

RESPONSE: Hit <RETURN>



Screen D.24

RESPONSE: Enter 7

```
CONDITION :          Clean

     GENERATED DIRT                Very Little

     AMBIENT DIRT                  Some / Almost None Enters Area

     REMOVAL OR                    Better than Average
     FILTRATION

     ADHESION                      Slight

     EXAMPLES                      Normal Office, Inspection Area


Press  <RETURN>  when ready to continue.
```

Screen D.25

RESPONSE: Hit <RETURN>

```
                DEGREES OF ROOM DIRT CONDITION

                DEGREE          EXAMPLE         CONDITION

                 1               6              Very Clean
                 2               7              Clean
                 3               8              Medium
                 4               9              Dirty
                 5               10             Very Dirty

     Enter DEGREE #  to select condition or,
           EXAMPLE # to see explaination of condition.


     Selection: 2

     Please indicate the normal time between fixture cleaning.
     Example:  Cleaned once every three years  =  36 months.

     Your cleaning cycle time (in months)?
```

Screen D.26

RESPONSE: Enter **2**, then Enter **18**

```
You have chosen:

A Room Dirt Condition of:  Clean

and a Cleaning Cycle of:    18  months


Are these correct (Y/N)?
```

Screen D.27

RESPONSE: Enter **Y**

```
                    ROOM INFORMATION REQUIREMENTS

(1) REFERENCE DATA:

    Building # None      Room # None                  Iteration: 1

(2) Room Use: General Offices            FC Requirements: 50

(3) ROOM DIMENSIONS:

                                                  Ceiling Height: 10
    Length: 40           Perimeter: 160           Fixture Height: 8
    Width:  40           Area:      1600          Working Height: 2.5

(4) ROOM REFLECTANCES:

    Ceiling Color: Winter White          Reflectance: 83 %
    Wall Color:    Silver Lining         Reflectance: 70 %
    Floor Color:   Crayon Blue           Reflectance: 20 %

(5) Room Condition: Clean                Cleaning Cycle:  18  months


Enter selection # (x) for data input, or (0) to continue:
```

Screen D.28

RESPONSE: Enter **0**

LIGHT SOURCE CHOICES

CHOICE	LIGHT SOURCE TYPE	
1	Incandescent	(INC)
2	Fluorescent	(F)
3	Mercury Vapor	(MV)
4	Metal Halide	(MH)
5	High Pressure Sodium	(HPS)

Enter CHOICE # for source selection: 2

Do you want to use a fixture stored in memory (Y/N) ?

Screen D.29

RESPONSE: Enter **2**, then Enter **N**

LUMINAIRE INFORMATION

Please enter the following information on the fixture you wish to use:
(Enter '0' to get help, when shown)

Fixture Make: Lithonia
Fixture Model: 2PM4-240

Maintenance Category (OR '0'):

Screen D.30

RESPONSE: Enter proper data shown, then Enter **0**

MAINTENANCE CATEGORIES

CHOICE	EXAMPLE	MAINTENANCE CATEGORY	AMOUNT OF WORK
1	7	I	Most
2	8	II	-
3	9	III	Some
4	10	IV	Some
5	11	V	-
6	12	VI	Least

Enter CHOICE # for selection or,
EXAMPLE # for explaination.

Screen D.31

RESPONSE: Enter **11**

MAINTENANCE CATEGORY EXAMPLE

CATEGORY V

TOP ENCLOSURE:

1 . Transparent unaperatured.
2 . Translucent unaperatured.
3 . Opaque unaperatured.

BOTTOM ENCLOSURE:

1 . Transparent unaperatured.
2 . Translucent unaperatured.

Press <RETURN> when ready to continue.

Screen D.32

RESPONSE: Hit <RETURN>

MAINTENANCE CATEGORIES

CHOICE	EXAMPLE	MAINTENANCE CATEGORY	AMOUNT OF WORK
1	7	I	Most
2.	8	II	-
3	9	III	Some
4	10	IV	Some
5	11	V	-
6	12	VI	Least

Enter CHOICE # for selection or,
EXAMPLE # for explaination.

Screen D.33

RESPONSE: Enter **5**

LUMINAIRE INFORMATION

Please enter the following information on the fixture you wish to use:
(Enter '0' to get help, when shown)

Fixture Make: Lithonia
Fixture Model: 2PM4-240

Maintenance Category (OR '0'): V
Distribution Type (OR '0'):

Screen D.34

RESPONSE: Enter **0**

FIXTURE DISTRIBUTION TYPES

TYPE	DISTRIBUTION	% UP	% DOWN
1	Indirect	90-100	0-10
2	Semi-Indirect	60-90	10-40
3	Direct-Indirect	40-60	60-40
4	Semi-Direct	10-40	60-90
5	Direct	0-10	90-100

Enter TYPE # for selection:

Screen D.35

RESPONSE: Enter **5**

LUMINAIRE INFORMATION

Please enter the following information on the fixture you wish to use:
(Enter '0' to get help, when shown)

Fixture Make:	Lithonia
Fixture Model:	2PM4-240
Maintenance Category (OR '0'):	V
Distribution Type (OR '0'):	5
Spacing-to-Mounting Height:	1.2
Lamp Type:	F40
Lamp Wattage:	40
Lamp Quantity:	2
Initial Lumens:	3150
Maintained Lumens (or '0' for default):	2770

Screen D.36

RESPONSE: Enter proper data shown

```
                    LUMINAIRE INFORMATION

  Please verify the following:

       Fixture Make:                    Lithonia
       Fixture Model:                   2PM4-240

       Maintenance Category:            V
       Distribution Type:               5
       Spacing-to-Mounting Height:      1.2

       Lamp Type:                       F40
       Lamp Wattage:                    40
       Lamp Quantity:                   2
       Initial Lumens:                  3150
       Maintained Lumens:               2770

  Is everything correct (Y/N) ?
```

Screen D.37

RESPONSE: Enter **Y**

```
                LUMINAIRE INFORMATION REQUIREMENTS

    Building # None          Room # None          Iteration:  1

 (1) LUMINAIRE INFORMATION:

     Fixture File #                    S/MH Ratio:              1.2
     Fixture Make:  Lithonia           Maintenance Catagory:    V
     Fixture Model: 2PM4-240           Distribution Type:       5

 (2) LAMP INFORMATION:

     Lamp File #                       Lamp Watts:          40
     Lamp Type:  F40                   Initial Lumens:      3150
     Quantity:   2                     Maintained Lumens:   2770

 (3) DIFFERENT SOURCE TYPE

Enter selection # (x) for data input, or (0) to continue:
```

Screen D.38

RESPONSE: Enter **0**

```
Critical        PFR   :    20
CU              PCR   :    80                          70
Values          PWR   :    70                          70
                RCR   :
                ------:-----------------------------------------
                      :
                 1    :  ( 1 )                     ( 2 )
                      :
                 2    :  ( 3 )                     ( 4 )

Please enter the following values from the Fixture's CU chart
to fill in the chart above.  If value is not given on Fixture's
CU chart, enter '0', or do manual extrapolation and enter value.

                          ( 1 )  ? 77
                          ( 2 )  ? 75
                          ( 3 )  ? 71
                          ( 4 )  ? 70
```

Screen D.39

RESPONSE: Enter proper values shown

```
        Please check:


    Critical CU Values from the Fixture Chart

        PFR   :    20
        PCR   :    80                          70
        PWR   :    70                          70
        RCR   :
        ------:-----------------------------------------
              :
        1     :    77                          75
              :
        2     :    71                          70


        Is everything correct (Y/N) ?
```

Screen D.40

RESPONSE: Enter Y

```
                    FINAL DESIGN CALCULATIONS

Building # None          Room # None                    Iteration:  1

Room Use: General Offices                               FC Required:  50

     CCR =  0.50         Ceiling Reflectance:  83       Effective:    76
     RCR =  1.38         Wall Reflectance:     70
     FCR =  0.63         Floor Reflectance:    20       Effective:    21

Fixture Make: Lithonia          Model # 2PM4-240        2  tube

     Critical PFR : 20                                  S/MH Ratio = 1.2
     CU       PCR : 80          70
     Values   PWR : 70          70                     Total LLF  = 0.727
              RCR :
              ----:--------------------                 Final  CU  = 0.745
              1   : 77          75
              2   : 71          70


Number of Fixtures Required:  23.44

How many fixtures do you want to use ?
```

Screen D.41

RESPONSE: Enter **24**

```
                    FINAL DESIGN CALCULATIONS

Building # None          Room # None                    Iteration:  1

Room Use: General Offices                               FC Required:  50

Fixture Make: Lithonia          Model # 2PM4-240        2  tube


     LLD =        0.879                 Floor Cavity Factor =    1.007
     LDD =        0.853                 Final CU Value =         0.745
     RSDD =       0.969
     Total LLF =  0.727                 S/MH Ratio =             1.2
                                        Spacing Criteria (ft):   6.6

Initial FC Level:      70              Fixture # Required:      23.44
Maintained FC Level:   51              Fixture # Used:          24


ENTER:
 (1)    To do another iteration of this room
 (2)    To go to Main Menu, clearing all variables
 (3)    To get a hardcopy, and return to this screen
?
```

Screen D.42

RESPONSE: Enter **3**, then Enter **2** after Hardcopy prints (see next page)

INTERIOR LIGHTING DESIGN PROGRAM OUTPUT

BUILDING # None ROOM # None ITERATION: 1

ROOM INFORMATION:

Use: General Offices
FC Required: 50

Length: 40
Width: 40
Perimeter: 160
Area: 1600

Ceiling Height: 10
Fixture Height: 8
Working Height: 2.5
CCR: 0.50
RCR: 1.38
FCR: 0.63

C. Color: Winter White Reflectance: 83 Effective: 76
W. Color: Silver Lining Reflectance: 70
F. Color: Crayon Blue Reflectance: 20 Effective: 21

Room Condition: Clean
Cleaning Cycle: 18 months

LUMINAIRE INFORMATION:

Fixture File #
Fixture Make: Lithonia
Fixture Model: 2PM4-240
Lamp File #
Lamp Type: F40

S/MH Ratio: 1.2
Maintenance Category: V
Distribution Type: 5
Lamp Quantity: 2
Initial Lumens: 3150
Maintained Lumens: 2770

Necessary Values from Fixture's CU Chart:

PFR	20	
PCR	80	70
PWR	70	70
RCR		
1	77	75
2	71	70

LLD: 0.879
LDD: 0.853
RSDD: 0.969
Total LLF: 0.727
Floor Cavity Factor: 1.007
Final CU: 0.745

RESULTS:

Spacing Criteria (ft): 6.6

Fixture # Required: 23.44
Fixture # Used: 24
Initial FC Level: 70
Maintained FC Level: 51

Hardcopy printout for permanent records

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VITA

Todd A. Grimes was born on 14 May 1955 in Columbus, Ohio. He graduated from high school in Troy, Ohio, in 1973 and attended Wright State University, from which he received the degree of Bachelor of Science in Engineering in June 1977. Upon graduation Mr. Grimes gained employment at ASD/DE, Wright Patterson AFB. There he worked as an electrical engineer, and in May 1982 became registered as a Professional Engineer in the State of Ohio. Mr. Grimes worked at ASD/DE until entering the School of Systems and Logistics, Air Force Institute of Technology, in June 1986. Mr. Grimes lives in Troy, Ohio with his wife and three children.

Permanent address: 1054 Meadow Ln.
Troy, Ohio 45373

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19. Abstract

Lighting design is a critical part of all building design processes for both new construction and renovation work. Performing lighting design properly takes a large amount of time and effort. The primary objective of this thesis effort was to develop a computer software package that would help base engineers perform the calculation stage of interior lighting design quickly and accurately.

Because the base engineer will have available to him many different types of computer systems, a second objective of this thesis was to make the program as transportable between computer systems as possible. The primary system that the program was designed for was the Wang pc system because of its wide spread use within the Civil Engineering community.

The program developed for this thesis effort is entitled LIGHT1A, and uses the Zonal Cavity Method of lighting design. LIGHT1A was developed to be menu driven to enhance user friendliness, and has a large data base filing system to allow the base engineer to store a number of lamp, fixture, and room color criteria. LIGHT1A was programmed in the language of BASIC to allow transportability between computer systems, and has been tested on the Wang pc, the Zenith Z-248, and the TeleVideo XL.

END

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